Governance Related to Energy Applications at the Community Level for Sustainability

Final Project Report

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Executive Summary

Numerous rural electrification programs throughout the world provide electricity to populations lacking service. The most effective and efficient method of reaching unserved households is through the extension of existing private or government-run utility grids. However, this is only true for communities located near an accessible network carrying sufficient capacity for extension. Remote and isolated communities are the last to be served, if ever, by grid extension, thus alternative solutions for energy sources must be considered. When an isolated community lacks any possibility of service from an established provider, then community owned and operated systems become an option.

For many communities lacking economic resources, having their own energy system is possible only through government or international donations. Often those programs don't give full consideration to long- or even short-term system management or resources to operate and maintain the system. All too soon, the systems fail to operate as intended.

There are three fundamental interdependent elements that enable the long-term sustainability of rural energy systems: robust system design and quality hardware; proper operation, maintenance and repair; and good governance and administration. These elements can be regarded as the legs of a support structure, such as a three-legged table – which we refer to as the *Table of Sustainability*. A weakness in any of the legs places whatever item supported by the table in jeopardy of tipping or falling. All three components are necessary for the sustainability of an energy system to reliably provide electricity whenever needed.

[1] Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC-04-94AL85000.

The objective of this project was to focus on the role of governance in ensuring/enabling sustainability as related to community owned and operated energy applications in rural off-grid locations. Governance, broadly defined as the mechanisms and means of public management, significantly influences the sustainability of community owned and operated energy systems.

An examination of how the elements of governance impact sustainability has been conducted by a Sandia National Laboratories team, sponsored by the U.S. Agency for International Development, and conducted in partnership with the Government of México's Fideicomiso de Riesgo Compartido, an agricultural extension service under the Ministry of Agriculture. The project consists of two parts: an energy system governance development project in two communities located in Veracruz, México, and the assessment of existing community owned and operated systems in the Mexican states of Quintana Roo, Sonora, Baja California Sur and Veracruz, and communities in Guatemala, Nicaragua and Perú.

Part I of the project entailed the implementation of an energy system governance model at the village level in two small communities, El Suspiro and Arroyo de Caña, Veracruz. The model focuses on the full and complete participation of community members to enable optimal system design and installation, and capacity training of best practices for maintenance, operation and repair, and governance/administrative procedures. In this model solar home lighting systems are owned by the community, rather than the individual, with responsibilities flowing in both directions between the users, the central community organizational unit and the support technicians and vendors. Through extensive community meetings and workshops the team helped the communities step through the processes of organizing a structure, identifying needs, selecting the hardware, establishing administrative practices, installing the systems and adhering to appropriate maintenance and repair procedures.

Over one and a half years have passed since the date of the photovoltaic (PV) system installations. During three follow up evaluation visits members of both communities expressed satisfaction with the accomplishments they have achieved thus far and with the operation of the PV systems. The impact of the project to the community members based upon survey responses include:

- The PV systems have been well maintained and continue to function as designed and intended;
- Improvement in the quality of life for the entire family, with a greater impact for quality of life on the women of the house;
- Greater confidence and success in the interaction with the municipalities as a result of having an organizational structure;
- Improved communication between the community members resulting from the regular meetings; and
- The administrative practices in place to govern the maintenance fund provide transparency to the process of fund collection and control.

Part II of the project is a review of the impact of governance to what has been successful and what has not in terms of system sustainability, determined through direct assessment and/or published information, on a sampling of communities with technology independent energy systems. Site visits and case studies of 14 communities in México, Perú, Nicaragua, and Guatemala were conducted. Framed within a historical social perspective, the review examined the origins of the systems, current system status, and factors contributing to successes or failures.

Common elements related to governance in those communities having community owned and operated energy systems which have been successfully providing electricity include:

- A strong central entity in charge such as a cooperative or committee;
- The existence of a foundation for an organizational structure;
- Plan for future costs;
- Tariff in place for operation & maintenance;
- Perceived service received for the fees paid;
- The existence of a resource in the event of system problems;
- Beneficial relationship with the municipality/state governments;
- Comprehensive training in optimal load management and system operation and maintenance;
- Compensation given to working members; and
- Administrative processes in place to manage and control fund or fee collection and placed under dual control.

Issues for those communities where the systems have ceased to operate in a useful manner include:

- No organizational structure or clear lines of responsibility;
- Minimal training provided for load management, system operation, maintenance and repair;
- Lack of planning for future costs; and
- Poorly designed systems with inappropriate components.

The primary conclusion from both Part I and Part II is that the likelihood of an energy system to be sustainable over the long term is greatly increased when all three legs of the *Table of Sustainability* are present. The most efficient use of time, effort, and financial resources are gained by an up-front investment paid to the overall planning of an energy project which pays attention to the quality and appropriateness of hardware, organizational responsibilities and ownership in governance processes, capacity building and user knowledge. Successful sustainability also requires sufficient time spent in the local area to develop, manage, and nurture the processes implemented.

1. <u>Introduction</u>

1.1 The Emergence of a Community Owned and Operated System

More than 2 billion people worldwide lack access to modern energy sources, with most of those unserved people living in rural areas. The reasons for this lack of access range from economic issues to physical geography. The most effective and efficient method of reaching unserved households is through the extension of existing private or government-run utility grids. However, this is only possible for communities located near an accessible network carrying sufficient capacity for extension. Remote and isolated communities are the last to be served, if ever, by grid extension, thus alternative options must be considered.

Remote and isolated communities are better suited to independent off-grid systems such as mini-grids with central generation or distributed generation sources at the homes. Because it is more expensive to provide electrical service to such customers, either subsidies of some kind are necessary to support a viable business or providers must charge more. Service in this case is provided by national/regional public or private utilities. In other cases a local provider runs several community systems, if so doing is economically feasible. When an isolated community lacks any possibility of service from an established provider, then some type of community owned and operated systems becomes an appropriate option.

For many communities which lack economic resources, obtaining their own energy system is usually possible only through government or international donations. Most also need sustained government subsidies for continued operation and maintenance. A few examples are evident of communities having an adequate economic base to secure systems directly, using their own financial resources derived from a local industry such as lumber or fishing.

The most common examples of community owned and operated systems are mini-grids powered by diesel generators and, where sufficient water resources exist, small hydroelectric generators. Diesel powered systems, using fuel which is often expensive to transport, are sometimes augmented with renewable energy technologies, such as photovoltaic and wind, with electrical storage to reduce the overall use of the combustible fuel. Another common model, especially in social-based government programs, is the use of distributed systems such as solar home systems (photovoltaic technology with energy storage). Although there is a tendency for individual ownership of the systems by the homeowner, community-based ownership may be preferred to enable sustainability.

In México many examples described above have been identified with the exception of a community-based hydroelectric system. The main electricity provider in México is the national government-owned Comisión Federal de Electricidad (CFE). The electrification rate is more than 95% and only the most remote communities are not served by the CFE grid. In the past, attempts by the government to serve remote communities by providing diesel generator mini-grids were met with opposition from CFE. Union rules require staff and management union members to be present at all CFE generating sites, thus making the costs even more prohibitive. As a compromise, CFE gave diesel generators and mini-distribution systems to the communities along with operation and maintenance training. These systems were not run by CFE, requiring the communities to organize and operate the systems independently.

Energy systems installed in rural off-grid communities enable better lives and promote cohesive communities, yet at the same time require appropriate capacity building and self-governance processes to manage, operate and maintain the technology. Often, energy systems are introduced into unserved areas with little or no attention placed on how the systems are to be properly managed for long term sustainability and thus the systems soon fail to operate as intended.

1.2 The Table of Sustainability

Sustainability is defined in this case as the ability of a system to adequately provide electricity as designed over the long-term (at least 5 years, ideally 10-20 years, or beyond). The sustainability of any type of system in a rural community, technology and application independent, is supported by three elements:

- Robust system design and quality components;
- Proper operation, maintenance and repair; and
- Effective administration and governance.

Figure 1. The Table of Sustainability

These elements can be regarded as the legs of a support structure, such as a three-legged table, which in this case we refer to as the *Table of Sustainability* (Figure 1). The table top is the sustainable foundation for an energy system of any type providing electricity. A sturdy table would have lateral segments that bind the legs together, representing training, education and communication. If any one of the three legs fails, the structure gives way and therefore endangers whatever item the table supports.

A robustly designed system is one that can function over a wide range of parameters. Such a system uses components that have self-protecting features with automatic reset ability. It is sized appropriately according to anticipated loads and suited for the environment in which the system will be used. Comprised of quality system components, it performs dependably in the manner in which the components were designed to perform. Proper operation implies that the users are knowledgeable of the capabilities and limitations of the energy source. Inherent in this knowledge is the ability to adjust their energy usage accordingly. Regular maintenance helps to prevent technical failures, and repairs when needed keep the system functioning.

The benefits of concurrently addressing governance and energy needs are numerous and synergistic. Proper governance focuses on citizen involvement and ownership in decision-making, representation and accountability. To improve the capacity of communities to administer and manage their energy resources while ensuring consistent and responsive service, local participation, selection and ownership of appropriate solutions to functional processes is essential. When community members are committed to a properly planned and governed project, the probability of long-term success and sustainability increases significantly. In the words of Professors Nasir El Bassam and Preben Maegaard, “Energy is one of the important inputs to empower people provided it is made available to the people in unserved areas on an equitable basis …This is only possible if the end users are made the primary stakeholders in the production, operation and management of the generation of useful energy.” [2]

The World Bank Group defines governance as the process and institutions by which authority in a country is exercised: the process by which governments are selected, held accountable, monitored, and replaced; the capacity of governments to manage resources efficiently, and to formulate, implement, and enforce sound policies and regulations; and, the respect for the institutions that govern economic and social interactions among them. [3] As applied to the “grass roots” rural village level the elements of governance include:

- The definition and implementation of business/administrative processes so that predictability and transparency are evident;
- Identification of responsible parties and the definition of their roles;
- Determination of how decisions impacting operating policies are reached, implemented, and enforced;
- Delineation of dispute resolution processes;
- The full involvement of community members from project initiation to lifelong system operation and management; and
- Communication with higher levels of government.

This report describes the role of local governance and administrative practices in enabling energy system applications to be sustainable in rural communities, as applied to community owned and operated systems. The theme is that well governed and administered, robustly designed, properly maintained and operated energy systems installed with quality hardware and partnered with comprehensive technical and administrative training, result in sustained energy systems. Strongly integrated, these elements can be considered a single concept for successful, sustainable projects. When one or more of the elements is missing or ineffective, the result is the failure of optimal system operation. The report is divided into two sections. Part I describes the activities associated with applying the elements of good governance to new electrification projects in two rural communities, from system design and installation to monitoring. Part II consists of an assessment of existing community owned and operated energy systems and focuses on evaluating the impact of governance in the successes or failures of system sustainability.

2. <u>Newly Installed Community Owned and Operated Energy Systems – Part I</u>

2.1 Background

In each of the southern Mexican states of Guerrero, Veracruz and Oaxaca, the Government of México’s Fideicomiso de Riesgo Compartido (FIRCO), an agricultural extension service under the Ministry of Agriculture (SAGARPA), proposed pilot demonstration projects based on renewable energy technologies for rural development and resource conservation in unelectrified regions in which replication to other communities was possible. FIRCO proposed to install

[2] El Bassan, N.; Maegaard, P. (2004), Integrated Renewable Energy for Rural Communities, Planning Guidelines, Technologies and Applications, Elsevier B.V., Amsterdam, The Netherlands.
[3] www.Worldbank.org/wbi/governance/pdf/programreview_1024ppt.

proven solar or wind powered energy systems for productive agricultural water pumping and to electrify community development centers in 3 communities, one in each state. The intent of FIRCO's proposal was to establish technically and economically viable energy pilot projects that might then be replicated in additional communities within the three regions, with the goals of providing better social and economic cohesion, and strengthening local technical capacity and infrastructure. The intent was also synergistic with the:

- Goals and objectives of the United States Agency for International Development (USAID) sponsored Global Village Energy Partnership (GVEP), a partnership in which México is a focus country;
- USAID/México 5-year Environmental Strategy (2004-2008); and
- Interests of the World Bank and Global Environmental Facility (GEF) for on-going development programs with the Government of México.

Partners of the FIRCO proposal included the Mexican Government, the community residents and the México Renewable Energy Program (MREP).[4] Leveraging with the FIRCO rural development project, Sandia National Laboratories (Sandia) proposed to assist the communities with identifying their energy needs, understanding and establishing governance processes and providing related administrative and technical training for the energy systems in the communities. Together with the governance activities Sandia proposed to provide technical assistance in the system design and specifications, bid review process, installation, acceptance testing and technical training of community users and local vendors relating to the energy source and its applications. The project evolved into one of integrated systems addressing economic development, quality of life, health and well being, and the environment, all within a framework of good governance.

Initially, the project was aimed at electrifying three community centers in each of the three states named above, however once selection discussions with project partners began the focus was placed on identifying three community pilot sites compatible and synergistic with USAID/México's environmental management plan. Several meetings were held in México City to explore avenues for collaboration among various Mexican governmental agency stakeholders for community renewable energy projects in México. Candidate sites included the Villa Corzo area in Chiapas, the Zongolica Region in Veracruz, areas of Oaxaca and also considered possible small hydro as well as PV systems.

Figure 2. The Mexican state of Veracruz, located on the east coast.

The focus was then further narrowed, based upon FIRCO's recommendation, to communities

[4] MREP is a program managed by Sandia National Laboratories and co-sponsored by the México mission office of the U. S. Agency for International Development (USAID/México) and the Solar Energy Technologies Program at the U.S. Department of Energy (DOE/SETP).

located in the state of Veracruz (Figure 2). FIRCO's activities through México's National Microcuenca plan and the resulting PV water pumping system installation was a source for key demographic information (Appendices E & F) used in the site selection process. Ultimately, for greater impact and more efficient use of resources and conservation of funds, the project was implemented in two communities closely located in the same region of the state of Veracruz.

2.2 Methodology

Working directly with community members, the team applied a management model (Figure 3) for community ownership of an energy system modified from one developed by the Intermediate Technology Development Group/Perú (ITDG/Perú). Adapted to fit a simpler situation, the community as an entity is the owner of the systems. An energy committee is entrusted to function as the technical administrative body which communicates with the vendor and the community leadership. The user/homeowner interacts with the energy committee and the general membership of the community through the asamblea. This model provides for individual participation, continuity, transparency, accountability and focuses on the roles and responsibilities of system technical and administrative management.

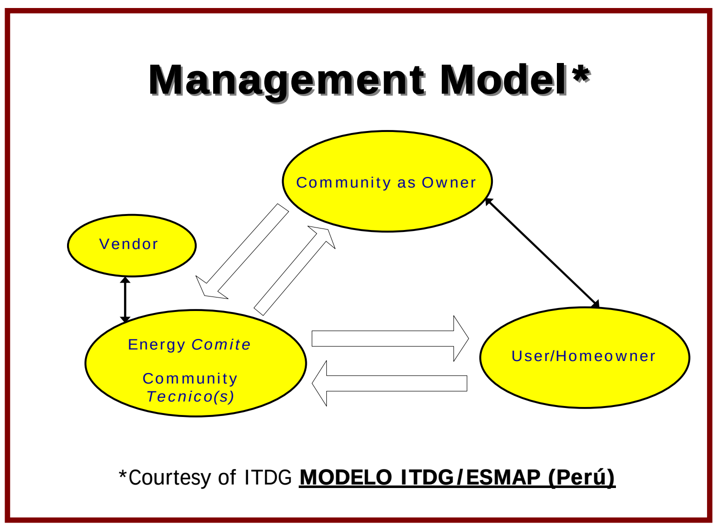

Figure 3. Management model of an effectively structured community owned energy system

Each visit to the two communities involved a workshop and/or facilitated group sessions (see Appendix A for visit dates and trip purpose). Through the presentation of available options, facilitated discussions, and information sharing, the communities were led through the process of identifying their energy needs and building the administrative management structure. Although the project team provided the information, the community made the decisions. Choosing the energy application with which they were most comfortable, the users signed the accords upon which all agreed (see Appendix C). Preserving trust and confidence between the team and the communities was accomplished by keeping to a schedule, following through with promises made, maintaining respect for existing social structures, and sharing experiences from similar projects and communities to establish credibility and provide consistency. Genuine warmth and concern for the people, crossing both cultural and language boundaries, assisted in establishing relationships with individual members.

With the support of the president of the municipality, and thus municipality representatives, the in-country partner (FIRCO) representative, the municipality representative and the Sandia team used a team approach for the initial meetings with the communities. The involvement of municipality representatives provided the avenue for the community to establish and maintain a line of communication with the municipality for future beneficial interaction. The role of the in-country partner was essential for the introductions of the Sandia team to the communities and continued support as related to the PV water pumping system technical designs. Although the FIRCO representative was present only at the first meetings, a municipality representative was present for most every community visit.

The support of the community leaders, formal and informal, was a key element to the full participation of all community members. The family heads within each community (majority male, see Appendix B) were the primary point of interaction; however the women of the community had a presence by virtue of their attendance at the meetings, with a few voicing their opinions. In each community the family head group identified a spokesman who functioned as leader. The women often participated in the process, although not regularly, depending upon the time of day the team visited. They were more apt to freely share information during the home visits, but were also normally present during each of the general technical and administrative training sessions.

One of the first objectives achieved was to establish a schedule of regular monthly community wide meetings. A regular schedule provided the framework within which the community had the opportunity to discuss related issues and set direction without the team's presence. Initially, our regular monthly visits provided the structure for the community to meet as a group and discuss issues. Once the assemblies became established, our meetings became training/information sessions to lay the groundwork for the management model.

The administrative business practices and recordkeeping focused on transparency and accountability. Financial recordkeeping and reporting methods were implemented through the use of a maintenance fund collection record and receipt system, and a report of fund status and activity to the monthly assembly. A unique maintenance log for each system and a user log for each user were implemented. Informal technical training was concurrent during the installation of the hardware and included general operation and maintenance themes. More detailed load management and battery maintenance training was directed primarily to the energy committee technicians, although the broader community was interested to be present.

2.3 Objectives and Activities

The work plan for the project encompassed eight objectives, the first of which was the selection of the communities (Figure 4). Using combined selection criteria developed by Sandia and project partner FIRCO and influenced by USAID/México, the communities of El Suspiro and Arroyo de Caña, Veracruz were chosen. The second objective was to develop a baseline assessment of existing conditions, structures and needs through interviews and site visits, and from data available from the FIRCO/Veracruz surveys. At this point both communities decided that rather than electrifying a community center, they preferred to have lights in each home. The technical specifications were developed and vendor bids requested with the community making the final decision. The definition and implementation of the governance and administrative processes involved extensive workshop discussions with the communities. Continuous orientation to the concepts of good governance and the importance of administrative practices became the foundation for successful implementation of the management model and assurance of future adherence. The ideas of microenterprise development as a potential source of income were introduced. The sixth objective, system installation, was conducted in partnership with the

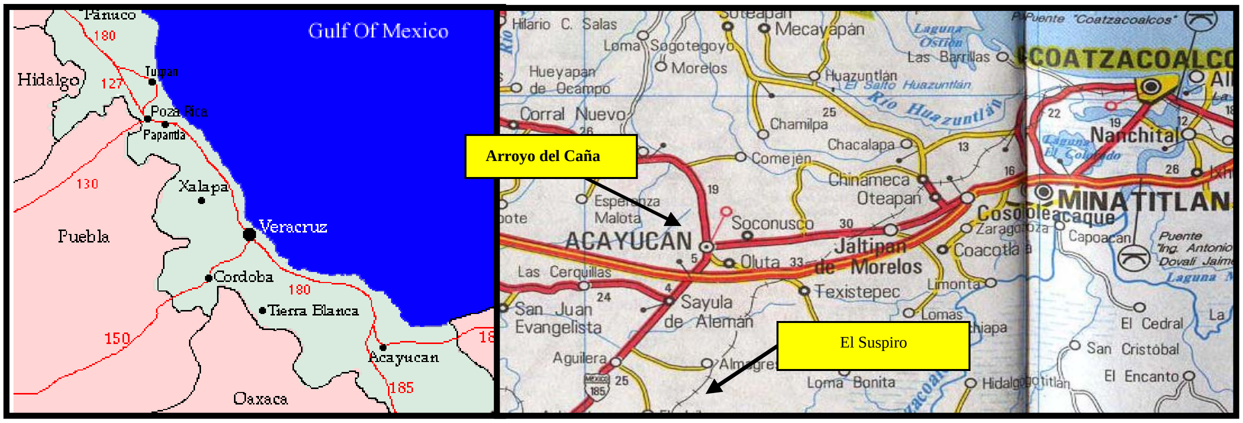

Figure 4. Map of Veracruz, México (left) showing the location of El Suspiro and Arroyo de Caña (right).

members of the community. Capacity building for the administrative/ management processes and technical operation and maintenance was continuous as well as conducted in conjunction with system installations. The final objective of evaluation and monitoring the status of project accomplishments brought the project field activities to a close.

2.3.1 Community Selection

Selection Criteria

After exploring possible collaborative opportunities with other Mexican governmental agencies and confirming the potential project sites were located within the USAID/México areas of interests, Sandia project partner FIRCO submitted a ranked list of communities located in the state of Veracruz which had been identified by the state office as communities with the most need.[5] Two other states, Oaxaca and Chiapas, were also considered, however were not recommended by FIRCO for various reasons. Combined criteria of FIRCO and Sandia and data gathered from the FIRCO/Veracruz Office were used to evaluate the communities as project sites.[6] The criteria were based upon the following:

- The likelihood of electrification through grid extension – Either due to geographic location or to size of community, grid extension is minimal to none;
- Size of the community – A small community consisting of 10 to 20 families is a manageable size for the scope of the project;
- Economic considerations – The ability to contribute to cost sharing for system hardware, future maintenance fund, potential for microenterprise development and overall income;
- Level of "*gana*" (desire) – The motivation of the population to participate and the willingness to learn and to work towards achieving a common community goal;
- Fundamental organizational structure – The existing level of organization within the community as a foundation from which to build; and
- Community center or natural gathering area – This was an initial criterion when the project was focused on community center electrification.

[5] Ing. Hilarion Verdejo Morales: "Proyecto de Energia Renovable para la Agricultura," Fideicomiso de Riesgo Compartido Gerencia Estatal Veracruz, Xalapa, Veracruz, September 8, 2003.
[6] Fideicomiso de Riesgo Compartido Gerencia Estatal Veracruz: "Proyecto Productivo en el Centro de Desarrollo Comunitario, "Arroyo de Cana," and "El Suspiro," Xalapa, Veracruz, September 2003.

Together with the respective municipality and FIRCO/Veracruz representatives, initial site visits to Arroyo de Caña and El Suspiro were completed in early February 2004. Group interviews of the family heads took place at each location and a tour of each community was also completed. As of the date of the first site visits, FIRCO had begun the installation of the PV water pumping systems in each community to be used for watering livestock and irrigation. The members of both communities expressed the desire, motivation, and capacity to work hard and to learn new things. They contributed financially to the PV water pumping systems and recognized the value to having structure and process in place to enable the success and sustainability of the systems. They had a foundation from which to develop administrative practices and procedures; the family head structure.

Opportunities existed in both communities to foster better health and environmental practices (using efficient wood stoves, latrines, etc.) for a broader collective positive impact on the environment, the quality of life, and economic well being of the inhabitants. Potential microenterprise development opportunities existed, such as the productive use of water pumping for the collective sale of agricultural items outside of the community and the construction and sale of the efficient wood stoves.

The two communities are also geographically located in close proximity, thereby reducing transportation costs. The decision was made that these two communities were suitable communities in which to initiate the project.

Description of Communities

Both communities are similar in that they were agriculturally based, unelectrified, with no running water or other basic services. The residents are poor with homes constructed of thatch, plank and block, usually consisting of two rooms. One room is used for sleeping in some cases up to 7 or 8 family members while the other room is for living/cooking purposes. There are no sheltered toilets; those needs are handled under the open sky. The majority of families use a three-stone open-fire wood stove for cooking, although one or two do have a gas stove. Most of the adults in the community have at least a first or second grade primary school education, some are illiterate. Each community has a one-room primary school.

FIRCO had installed the PV water pumping systems in each community for water to be used for grazing livestock and irrigation purposes. At the time of the initial visits, the pumping system in El Suspiro lacked conduit pipes and both communities lacked a tank. As a result of the team's visit, the relationship between the community of El Suspiro and the municipality opened up to the extent the municipality agreed to provide the funds to complete the system. Both communities contributed what little financial resources they could to their respective systems, an amount of approximately $11,000 pesos (about $1,100 US).

Arroyo de Caña

Arroyo de Caña is approximately a 15-minute drive northwest from the center of the city of Acayucan, in the municipality of the same name. Initially the road is paved, and then transitions to a well-graded and cleared dirt road. The climate is humid and tropical with a landscape of gently rolling hills and dense tropical fauna. Evidence of deforestation is apparent. Arroyo de Caña is a community of abundant natural resources but poor economic resources. The residents of the community grow maize for self-consumption; sporadic vegetable gardens exist in which they grow a few vegetables such as tomatoes and zucchini. Several varieties of fruit and citrus trees are native to the area. Most homes are constructed of wood planks, adobe or mud brick and have thatched roofs. The one-room school and one or two other structures are constructed of concrete block and have tin roofs. Basic services are non-existent; water for domestic use is manually hauled from a well some distance from the homes, lighting is through the use of kerosene/petroleum lamps and candles, and there are no latrines. The nearest medical care is in the city of Acayucan.

Access road to El Suspiro crosses a broad flood plain.

One-room school house in Arroyo de Caña is often used as a meeting place.

Figure 5. A closer view of the two project communities

El Suspiro

Access to the community of El Suspiro is via the municipality of Sayula de Aleman. El Suspiro is approximately a 1-½ hour drive southeast from Sayula de Aleman, traveling partially by paved road, mostly by dirt road. The climate is humid and tropical with a hilly landscape that fans out into a broad flood plain. The flood plain must be crossed in order to reach El Suspiro, which lies in the hills south of the plain. Due to the mud and flooding during the rainy season, El Suspiro is relatively isolated with access limited at times during heavy rainfall. The family heads of each of the 11 families residing in El Suspiro were gathered at a clearing that serves as a "central plaza," easily accessible to all residents. Adjacent to the clearing is the school, a chapel, and a shelter used for young livestock. Because El Suspiro is located on the summit of a hill, the layout of the community is compact. Soon after the initial visits a twelfth family moved to the community. Similar to Arroyo de Caña, the residents of El Suspiro cultivate maize and beans for self-consumption and raise chickens. Few families grow any vegetables near the home. Homes are constructed of wood and thatch with an occasional concrete block structure. Basic services are non-existent; lighting is through kerosene/petroleum lamps and candles, domestic use water is hauled from a well and there are no latrines, although a rudimentary structure serves the purpose in one example. The nearest medical care is at a distance of 8 km.

2.3.2 Governance Baseline Information

The goal of this objective was to gather information to identify the formal and informal community leaders, existing social and organizational structure, lifestyle, and economic capacity. The baseline information is a collection of geographic, demographic and social data that becomes the baseline from which the project moves forward.

The Sandia/ FIRCO team is welcomed into a home during a site visit.

Figure 6. Typical residential structure

A comprehensive view of the two communities was developed during the initial visits to Arroyo de Caña and El Suspiro which took place during the months of February and April 2004. General observations, discussions with the community family heads and individual interviews formed the basis for this task. In summary, the two communities are similar in that neither one has basic elements for health and well being: potable water, electricity and latrines. They are different however in tone and relative sophistication; Arroyo de Caña is located a short distance from the municipality of Acayucan and thus the residents look more outwardly, while El Suspiro is more isolated and therefore the residents more self-contained. Both communities have a community leader/spokesperson determined through a casual selection process, both grow crops for self-consumption, current lighting needs are met with kerosene lamps and candles, and water is hauled from a well some distance from the homes. The going price for a liter of petroleum is about 8 pesos per liter and they consume two liters per month.

Arroyo de Caña: This community is defined by the school attended by the children of the community members. A group comprised of the family heads (18) attended to issues which impacted the community. At the time of the initial visits there were no regularly scheduled meetings, or formal structure to this group. The leader/spokesperson chosen by the group remained in that role as long as he performed the job satisfactorily. The process generally used for problem/conflict resolution was to complain among themselves until something became an issue, then meet to arrive at a solution. Women, generally not part of the family head group, are called upon to act with authority in the absence of the men. It is interesting to note that the first meeting between FIRCO, municipal authorities and the community took place with the women of the community, as

Municipality representatives participate in open dialogue with community members of El Suspiro.

Figure 7. Meeting with villagers

the men were away working. The main location for social gatherings and celebrations is the school, the only structure used for this purpose. Income is generated by the sale of wood, working in the fields; while some residents hold service jobs in nearby Acayucan.
When presented with topics and ideas such as managing a community fund, the idea of an organization for productive use, or solving problems related to energy system operations, it was clear the group understood the ideas and importance of an administrative structure, however had no thoughts as to how they might be addressed. They were responsive, thoughtful, appeared interested in exploring the ideas further, and motivated to receive training. Interest was particularly expressed in the agricultural arena for growing a broader variety of crops and trees best suited to the soil and climate of the area, as a productive application.

A crowd gathers to learn about the benefits of the efficient wood stove in Acayucan, Veracruz.

Figure 8. Residents of Acayucan

El Suspiro: Perhaps because of its relative isolation, El Suspiro is a unified community consisting of 12 families, all living within a small more compact geographic area. A group consisting of the heads of the families presented themselves as the governing entity. The leader holds the leadership position until it is determined he is not doing a satisfactory job, or until he no longer wishes to keep it. No formal election process existed nor did they have regularly planned meetings. Any issues that needed to be addressed were settled in ad hoc meetings. The school is sometimes used for alternative purposes besides teaching the 22-plus students, but the sheltered clearing is the most common location where residents gather. Income is generated from working the land and grazing cattle.

An immediate positive impact of the initial visit was the open dialog that took place between the family head group and the municipality representatives. The community expressed a concern of having been ignored by the municipality. As a result of the ensuing discussion, the relationship with the municipal representatives was strengthened and the community was able to draw upon available municipal resources to obtain the water tank and pipes for the PV water pumping system. They were anxious to participate in any kind of capacity training to improve their standard of living.

2.3.3 Potential Income Source

The goal of this objective was to assist with the identification of natural resources and/or culturally based activities within the communities that could provide a source of income

A stove in progress and the finished product, Sayula de Aleman, Veracruz.

Figure 9. Efficient wood stove workshop

for the residents. This activity would serve two purposes: income for a fund for the proper maintenance and perhaps enhancement of any of the systems installed in the community, and an increase in the overall economic well being of the villagers.

One idea developed by the residents of Arroyo de Caña was to grow medicinal plants, package and sell them in the marketplace at Acayucan, the nearest metropolitan area. They came up with an ad-hoc list of 25-30 plants with medicinal properties that could be found growing naturally in the area. Various ideas were explored as to how to grow the plants: each family grows a select variety in their own plots of land, or each family donates a portion of land to work as one community plot with all varieties growing on the community plot, etc. Concerns regarding the need to buy and use pesticides were addressed with the idea of one or two residents attending an organic farming course. A one-week organic farming course offered at a ranch near Xalapa, Veracruz, free to rural residents, including accommodations minus travel expenses, was an option to be explored.

The residents of El Suspiro were not able to as easily arrive at alternative activities but expressed ideas about the possibilities of growing crops that aren't as readily available in the area to sell at market. Since a main activity in El Suspiro is raising cattle, ideas for making products related to milk such as cheese or yogurt, were also discussed. Similar concerns for resolving issues such as the pests that destroy crops and irrigation during the dry season arose and were similarly addressed with the idea of the organic farming course. The construction of wood stoves with the complementary cultivation of woody trees generated interest as well.

Another possible activity explored was the construction of the efficient wood stoves for sale outside the community, perhaps to people living in the municipalities of Acayucan or Sayula de Aleman. An example of similar successes with the wood stove enterprise in other communities was discussed. The benefits to overall health and well-being as a result of reduced smoke in the home and the benefits to the environment as a result of the reduction of firewood usage were covered. Interest was sparked to pursue municipality involvement in the support of a workshop on the construction and benefits of the efficient wood stove.

Three separate workshops were held on the construction of the efficient wood stove. One all-day workshop was offered in each of the municipalities of Sayula de Aleman and Acayucan for portable and fixed stoves, and one half-day workshop was offered for just the portable stoves in El Suspiro. The municipalities sponsored the workshops and paid for the instructor's travel costs. The workshop in Acayucan generated the most interest in the stoves because it was held in a very open, public location with good exposure. Representatives from several nearby communities were also present.

The traditional and efficient wood stoves operating side by side.

Figure 10. Kitchen stoves in use

Those owning the new efficient wood stove as a result of the workshops indicate it functions well but they are not using the stove exclusively. The stove is used to supplement cooking activity with the traditional stove. During home visits for the PV home lighting system installations, both examples of exclusive usage and concurrent usage with the traditional stove were evident. Users conveyed satisfaction with the operation of the smaller stoves indicating they particularly liked its portable nature. Those using both stoves indicated they used the smaller stove less frequently, and used the traditional stove for large quantity cooking.

Both communities were given the suggestion to form committees of three to four people, including women, which would be responsible for organizing and taking the next steps to forming a microenterprise. A formal business structure will need to be established with assistance from the municipality to complete the necessary documents required to register the enterprises. Arroyo de Caña formed a stove committee with a woman sitting as president.

The project plan was to use the irrigation potential provided by the PV water pumping systems installed by FIRCO to enable the development of income producing agricultural activities. Unfortunately, the pumping systems were not adequate in design or function to effect the development of a microenterprise during the project’s duration.

2.3.4 Administrative/Management Structure

The goals of this objective were to apply a management model for the management of community owned system by working through a committee structure establishing rules, roles and responsibilities and defining the relationships and responsibilities between the users, the community as owners and the vendors.

The activities were fully integrated with the other objectives. Defining the structure through committees, applying a management model, formalizing an agreement among the people and establishing the recordkeeping processes were components to establishing the administrative management structure

Committees
Using a committee structure, a core group of residents was selected by each community to be the “managers” of the energy systems owned by the community as a whole. The energy committee is tasked with responsibility for all aspects of the systems: determining the fee structure for and managing the maintenance fund, implementing the consequences when one does not contribute, contacting the vendor service representative when something goes wrong with a system, etc.

Management Model
The management model applied to this project is based upon a successful management model used by the Intermediate Technology Development Group/Perú for community owned and operated systems. Modified to fit a simpler situation, the community as an entity is the owner of the systems, an energy committee is entrusted to function as the technical administrative entity that interacts with the vendor and the community leadership, with the user homeowner interacting with the committee.

Each community also selected "technicians" to be the committee experts, and thus community experts, on system technical issues. The technicians are responsible to the energy committee, which in turn is responsible to the entire community. Although every member of the energy committees received technical operation and maintenance training, the technicians were provided more specific technical and administrative training, since they will function as the primary energy system manager and interface with users and vendors. The technicians are also responsible for the technical recordkeeping for the systems. Both communities held their first monthly meeting at the end of April 2004, attended by representatives from each family to report on the status of community projects, maintenance funds, and to discuss any on-going issues.

Agreements

A representative from every user family receiving a system formally signed an agreement affirming principally that the systems belong to the community, each user must contribute to the maintenance fund, and each user understands the rules and consequences to which they have agreed. This agreement is revised as circumstances require or as the communities evolve and adjust to changes. For example, during the maintenance check in one home, after the systems had been in operation for about a month, it was found that a radio was improperly connected directly to the battery. This could cause damage to the system. The energy committee will recommend an amendment to the agreement to provide for consequences should a user be negligent with the operation of the system.

Recordkeeping

The energy committee technicians are responsible for a monthly maintenance check which is recorded on a unique maintenance record for each system, kept by the committee. This form is used to note the date the maintenance check was performed and the status of the battery water level (fill if necessary) the condition of the cables and connections to the load, the amount of shade on the panel, etc. By recording this information on the form there is a historical record of normal system performance. The user in turn has a User Maintenance Form to keep in the home to validate the maintenance check was performed as well as to note any questions or comments about how the system is operating. To ensure transparency with the collection of the maintenance fund, a recordkeeping and receipt system was established to record each user's contribution, which then balances with the cash collected. The treasurer reports the activity of this "account" to the general asamblea at each monthly meeting.

The importance and value of good recordkeeping and accountability were demonstrated and reinforced to the community when it came time to disburse funds to the vendor after the system installation in Arroyo de Caña. The community had deposited its portion of the hardware cost to an account in the municipality; however the municipality, under an interim presidency while the elected president ran for another office, was seemingly unaware of this account activity. Also, initially, the interim president's office seemed to be

Sandia team and residents of Arroyo de Caña discuss energy system options.

Figure 11. Exploring electrification options

unaware of the previously reached agreement to contribute to the hardware costs. Once the community representatives presented their receipts, and after lengthy discussions with responsible parties, the situation was resolved and all funds were appropriately identified for disbursement.

2.3.5 Community Selects Energy System Application

The communities were able to reach an informed and participative decision as to the energy system application option that best fit their needs and in which they as an entity have full ownership.

Over a period spanning two months, various examples of energy system applications were discussed, among which included photovoltaic (PV) powered school distance education satellite, electrification of a community center, refrigeration and home lighting systems. The school distance education system, based upon the EDUSAT[7] network, can also be used for other purposes when not in use by the school. PV-powered refrigeration might be used in a central location for a productive use purpose; home lighting systems would power 2-3 lamps in each home and possibly a small radio tape player or small television. The residents considered all of the options and identified their preferences. Both communities were unanimous on the idea of home lighting systems, primarily for three reasons: the flexibility to extend family activities after dark on an individual basis; the reduction of the inhalation of kerosene lamp fumes in the home when, for example, positioned closely to do homework; and because they already had this option in mind from the initial FIRCO/Veracruz meeting. In particular, the El Suspiro group was quite interested to know what small appliances a PV system would support. In addition to energy systems, the use of efficient wood stoves, potable water filtration systems and dry latrines were also introduced. The essence of the discussions suggested that meeting elemental needs for a basic standard of life, such as lights in the home, a healthy environment and clean safe drinking water, are priorities over productive use applications for the villagers.

Under the watchful eyes of the vendor technician, community members assemble a PV array and affix to the top of the pole.

PV home lighting system is ready to provide energy in El Suspiro.

Figure 12. PV system installation

Once PV home lighting systems were selected as the application of choice, activities focused on the details of system sizing, vendor solicitations, the review and selection of the most appropriate bid, and finalizing cost sharing options between the communities and the municipalities. The energy committee of El Suspiro chose

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[7] EDUSAT is a satellite-based system with hemispherical coverage that reaches thousands of participating schools. It is managed by the Office of Educational Television within Mexico's Secretariat of Public Education.

the larger, enhanced PV energy system, requiring the negotiation of a cost sharing arrangement with the municipality president. The final system selected was a 100 watt (W) solar array with two 6 volt (v) batteries connected in series, a charge/load controller and a 400W inverter (see Appendix D for technical system information).

The community of Arroyo de Caña is more disbursed geographically and less unified socially, thus necessitated more organizational time to gain progress on a decision. The majority of the members of this community opted for the 75W system with low voltage DC (direct current) connection and a 12v battery. Four users chose to upgrade to the larger 100W option, comparable to the system chosen by the community of El Suspiro, requiring a greater user cost share for those four. The municipality agreed to contribute the equivalent cost of two systems. A total of 21 systems were installed in this community.

2.3.6 Energy System Installation

The technical specifications for the solicitation of vendor bids for hardware purchase and system installation were developed with full and active user participation, to encourage a broad base of system knowledge across the community.

The system installations took place in two stages: Stage I was the 13 systems installed in El Suspiro in June, with Stage II the August installation of 21 systems in Arroyo de Caña. The PV home lighting systems were installed at the individual residences but owned by the community as an entity.

A solicitation for technical bids for the energy systems was directed to a list of seven vendors selected from a FIRCO vendor list, primarily based upon location. Out of the seven vendors, five responded, with three of the five bids determined to be viable bids. After reviewing the bids with the energy committees, and with technical guidance provided by the project team, the energy committee selected one vendor. For the final installation plan, a detailed definition of system specifications took place to ensure the most appropriate components and quality hardware were available. Since the specifications were written to solicit bids for three system sizes, each community had the option of selecting the size that best met the needs of the residents from both an economic standpoint as well as energy needs standpoint. The majority of residents of Arroyo de Caña (17) opted for the 75W lighting system that provides sufficient energy for 2-3 lamps; four users selected the 100W system under a user cost share arrangement. All users in El Suspiro selected the larger 100W system. The energy committee of El Suspiro was able to negotiate municipality support, together with a cost share from community members, for the cost difference between the basic and the larger energy system. The systems were funded through a cost share among USAID/México, community, and municipality funds.

The entire community of El Suspiro actively participated in the more than two day installation; assembling the arrays, positioning and digging the holes, stabilizing the support poles, and positioning the lamps in the home. The benefit of this participation beyond the obvious labor component was the familiarity the user developed with the systems. Each location was fitted with one 20W and two 13W energy efficient lamps, the final placement of which was determined by the user based upon the general recommendations of the technical team. Informal training to community residents took place concurrent with the system installation. Similarly, community members were actively involved in the four-day installation in Arroyo de Caña however, due to the four day span, of course not every member assisted with every installation.

2.3.7 Capacity Training for Administrative/Management and Technical Matters

Teaching the concepts and processes of good governance to the community and providing the technical knowledge of system operation to the energy committees as the systems were installed, empowered the community and members of the energy committee to be knowledgeable managers of the PV systems.

The themes of governance – who operates, maintains, and uses the system, who pays for the usage, what is the pay structure, what is the plan for maintaining the system, who benefits from the productive application and how, etc. – were an on-going training process throughout the duration of the project. Each meeting with both the community at large and the energy committees was a "workshop" session during which the management model was defined and put into practice. Points of discussion were agreed upon, such as how the committees would handle potential conflicts which then became part of the agreement. A representative from every user family receiving a system signed a document formally affirming the matters of agreement reached to that point, principally that the systems belong to the community, each user must contribute to the maintenance fund, and each user understands the rules and consequences to which they have agreed. To ensure transparency with the collection of the maintenance fund, a recordkeeping and receipt system was established to record each user's contribution, which then balances with the cash collected.

After the committees had been in existence for a year it became important to address and formalize an election or leadership selection process. Revisions to the community agreement were planned for an election process including candidate criteria, voting procedures, and the method by which the agreement can be amended to address such issues as, for example,

The El Suspiro "energy committee" listens attentively to instructions.

The importance of load management is stressed during the community training session.

Members of the energy committee put into practice their newly learned skills by replacing a controller thought to be mal-functioning.

Figure 13. Capacity building

increasing the amount of user contributions to the maintenance fund. The value and use of a bank account was also explored with the communities.

Once all 13 installations were complete, both the vendor technician and the Sandia team conducted a formal load management training session attended by most of the community. More detailed operation & maintenance and administrative processes training was specifically directed to the energy committee members by the Sandia team, with an emphasis placed on battery maintenance and charge management. The committees were also outfitted with system maintenance kits containing the appropriate tools necessary to perform a monthly maintenance check on each system; checking the battery water levels, charge status, connections, cables, lamps, verifying proper load usage and ensuring the solar panels remain free of shading. The committees were also outfitted with waterproof file boxes, plastic file folders, receipt books, pens, paper and templates for the forms. The monthly check is recorded on a unique maintenance record for each system, kept by the committee. A user form is also kept with each system.

Problem solving skills were demonstrated when one system failed to operate properly, requiring additional testing. The controller, thought to be mal-functioning, was replaced by the committee technicians, who took advantage of the opportunity for some hands-on experience. It was soon determined the problem was with the wires that connected the panel to the controller, which were inadvertently reversed at the panel connection during installation. The vendor was responsible for this correction.

2.3.8 Evaluation

Two preliminary monitoring and evaluation visits took place in December 2004 and February 2005, with a final evaluation visit in December 2005, approximately one year plus a few months after the system installations. The strategy was to return to the communities after a significant period of time, to evaluate the success of the various components of the overall project: the effectiveness of the committee structure and administrative processes in place (making adjustments and recommendations where needed), interaction of the community members, and reinforcement of training provided.

At the time of the first two follow up visits the energy committees in both communities were functioning effectively. They had been performing the system maintenance checks, using the files established to note system status and the dates of the maintenance checks. In Arroyo de Caña they adjusted the frequency of the maintenance checks to every fifteen days instead of once a month because they found the batteries needed water on a more frequent basis. In El Suspiro the committee technicians had several questions to ask the Sandia team based upon questions users presented to them. The monthly maintenance fee was collected and duly recorded. They held the monthly meetings although an occasional change in the date has occurred. A spot check of the systems by the Sandia team was performed and user interviews conducted. The systems were functioning properly, with the families indicating they are using the lights on average 2-3 hours per evening.

From a social and cultural perspective, the team’s female member visited a total of 23 homes (8 in El Suspiro and 15 in Arroyo de Caña) to interview the women at a time when most of the men were out of the home. The interviews were focused on exploring the opinions of the women regarding the changes they have observed in the community and in their daily lives as a result of the project implementation, specifically the arrival of electricity and the use of the efficient wood stoves.

A consistent response from both communities reflected the opinion that their lives were overall brighter (no pun intended, this was a literal translation) and more interesting now that they had lights. They weren't necessarily more productive as much as they now have the option to be flexible as to when they completed their work in the home. The evening routine was lengthened and they were going to bed just a little later. For example, two families living in close proximity used the outdoor lights to illuminate volleyball games for the "neighborhood" adolescent kids. There was an exception to this; in one home the use of the lights at night was minimized so as to not upset the biological clock of the chickens inside the house. One woman indicated that now, with the PV powered light, she is motivated to get up and do something in the evening and is happier doing it because the light is brighter. Another woman indicated her son was able to come home at night after being away from the house with friends and do his homework late in the evening. Several of the women commented that they felt safer and more comfortable at night, especially if they needed to go outdoors, or if they heard an unusual noise.

Their impressions of the level of communication within the community were that there is much more interaction and discussion among the members of the community than previously existed. Most women did not participate in the monthly community meetings, preferring to let the men represent the family. Those that did attend saw the meetings as an opportunity to socialize with other women and talk about the issues that concerned them – illness in the family, home life and other familial topics.

One of the concerns the Arroyo de Caña energy committee technicians expressed was the improper connection of a radio directly to the PV system battery discovered during one of the maintenance checks. From this a detailed training session was developed and held in a follow-up visit to address how to properly connect a radio or other small electronic device to the system

The Sandia project team traveled to Veracruz the first week of December 2005 for a final visit on present project funding. Once again, the objectives accomplished during this trip included interviews of system users in El Suspiro and Arroyo de Caña to evaluate the status of the administrative processes, and to determine the impact of the project on the residents in terms of economic progress, social interaction and communication, transparency and quality of life. The purpose was also to ascertain PV system usage patterns and to provide any necessary follow-up training and technical support to the community tecnicos.

During the last trip the team conducted on-site interviews at 11of 13 system locations in El Suspiro and 19 of 21 locations in Arroyo de Caña.[8] Time, logistics and accessibility issues prevented the team from visiting the four remaining locations. Each family was asked the same questions; despite the differences between the two communities the responses were quite similar,

[8] Raw survey results are available upon request.

and qualitative rather than quantitative. A summary of commonly reported information from both communities follows:

- Regular monthly meetings are held, with the exception of the month of December in Arroyo de Caña. Due to the Christmas and New Year holidays the next meeting was held in January 2006;

- The lines of communication within the community are improved and continue to improve as a result of the process of organization and the regular meetings. There are differences of opinion but thus far they have been able to openly discuss them;

- The community leaders have greater confidence and success in presenting requests to municipality representatives;

- The funds collection and record keeping processes are understood by all and transparent. Collection problems and/or missed payments are openly discussed and known among the residents. Exceptions for hardship cases have been agreed upon; there are some payment issues yet to be resolved;

- Although many could not state the exact balance of the maintenance fund, it was apparent they had been receiving reports from either the president or the treasurer. They indicated confidence in the information they received and no complaints related to the status of the funds were presented. They were aware of the purchase of light bulbs and other costs incurred for small repairs and replacement parts;

- The women report they now have a choice as to when certain tasks may be accomplished. The electricity in the home has given them greater flexibility for the completion of daily routines and thus that much more control over their lives;

- All reported a much greater sense of well-being, comfort, and security from brighter and more consistent illumination in the home. The fact that electric lamps did not blow out during the recent hurricane and that they had lights during the entire storm was frequently mentioned;

- The economic benefit is balanced for most families in that although they are saving the costs of fuel lamps, candles and in several cases small batteries, the contribution to the maintenance fund makes up the difference. A few families had been spending more of the family budget on lighting supplies and thus actually have a net gain; and,

- None of the families were using the electricity in the home for a productive enterprise.

El Suspiro treasurer Juan Flores Lopez collects the maintenance fee from community members during the December assembly.

Figure 14. Village assembly held in El Suspiro

El Suspiro

The team's visit coincided with the assembly held the first Sunday of each month. Members of the community that are available attend the assemblies and normally pay the maintenance fund contribution at the meeting. If they miss a meeting they either pay when they next see the Treasurer or at a subsequent meeting. The community reports that there have not been any major issues with the maintenance fund which they have not been able to address or resolve. Over the past year there has been a successful transition to a new community president and other officers.

The energy committee members brought the file boxes containing system folders and other documents to the meeting. The president, Julio, opened the meeting while everyone passed around the system folders from the file box. Each person noted the status of the system in his home on the record sheet. Concurrent to this activity the treasurer, Juan, accepted payments, noted them in the payment register and issued receipts. He used a small hand-held calculator to sum totals and report.

Detailed records dutifully kept by the treasurer were tallied and the totals reported to the assembly by the president. Receipts presented to the users upon payment provided confirmation of the payment received. The fund has thus far been used to purchase a battery protector to replace a malfunctioning controller and replacement bulbs. The battery protector purchase was made from a vendor in Acayucan and after hearing the amount paid, the team advised them they had been charged too much. This was later addressed when Rubén and Juan came to Acayucan where the team assisted them with identifying a fair and knowledgeable vendor.

During this particular meeting the president reported on a recent meeting at the municipality (Sayula de Aleman) requested by FIRCO representatives for the purpose of completing a survey on the PV water pumping system. The survey was to determine how well the system was working. After replacing the pump a few months ago and adding additional panels last year, the water pumping system now pumps enough water to nearly reach the middle of the community. A central "water station" has been established adjacent to the home of Genaro Flores Lopez, which replaces the originally planned concrete storage tank built for that purpose at the top of the driveway near the entrance to the community.

One result obtained from the home surveys was that each user had been purchasing bottled distilled water for the batteries and checking the batteries on their own. Instead of the tecnicos visiting each home on a scheduled basis, the community has tweaked the process whereby the users report on the status of the systems as part of the monthly assembly and the tecnicos visit if necessary or when requested. A discussion ensued during the meeting on the use of the community stovetop water distiller and the importance of clean batteries and system components. They must decide upon a plan to share the distiller so that there is no need to purchase water.

The tools are in the possession of the ex-president and there is some reluctance to request they be handed over for general use. This was addressed with the appropriate individual as well.

Overall, the community reported the PV systems were operating well and as designed. However upon inspection there is evidence of corrosion and dust and dirt accumulation. The systems are not being thoroughly cleaned. The batteries and battery charge levels are in good shape and appropriate loads are connected. The users are doing a very good job of monitoring and managing their load usage.

One system had a problem with its 400W inverter. When opened, the team found that it was filled with dust, dirt and nests, which most likely caused the short. These small inverters are made for use in automobiles and recreational vehicles to power AC (alternating current) appliances from the 12v battery via the cigarette lighter or direct connection. The environment is relatively clean.

Six households reported the use of the efficient wood stove. Of the six, one is used in a remote location for working in the field, four are used concurrent with the traditional stove and one is used only occasionally when there is a great deal of cooking to do. In one case two different individuals asked one of the women if she would sell her stove. This planted another seed for the possibility of establishing a microenterprise.

Arroyo de Caña

The most recent community meeting took place on November 26, 2005, the last Saturday of the month. At that time the assembly voted to dispense with a December meeting due to the upcoming holidays and to the fact the regular meeting would have fallen on New Year's Eve. The next meeting will take place the last Saturday in January.

Presidente Agustino and other members of the energy committee met with the Sandia team and provided the team with preliminary information regarding the current state of affairs in the community. They reported that generally all was going well except for a few individual users who were not paying the monthly fee, for various reasons, or weren't paying the fines for missed meetings. Although the assembly gave approval for the hardship cases (for example, one user lost his leg and thus is unable to work) they were struggling with how to handle the other non-payment issues. Using a strict interpretation of the agreement, the systems should revert back to the possession of the community once

A chewed-upon grounding wire is repaired by technicians Alfredo and Agustino in Arroyo de Caña.

Figure 15. Community technicians at work

the number of defaulted payments reaches unacceptable levels. An ongoing discussion ensued as to how best to deal with those that are not paying. Weighing various options, the committee will need to develop a recommendation for the general assembly to consider and vote upon.

As the team surveyed the community it was apparent that all systems are very well maintained by the technicians; very clean terminals, little to no corrosion, fully watered batteries and evidence of correctly installed connections. Four new tecnicos have been designated from among the youth of the community and are in the process of learning about the systems. The group has instituted a system for sharing the use of the stovetop water distiller. Alternating the possession of the stovetop water distiller between users allows each to distill a sufficient amount of water for the needs of the battery as well as other uses, if so desired.

In this community only four systems included an inverter at the time of installation. Since the installation, one user connected an inverter. With the one exception of the user connecting the inverter, the community has been managing the loads very well – all systems were charged appropriately and functioning well. The technicians have replaced blown fuses and spliced wires chewed by livestock. They have become quite skilled at the job of system operation and maintenance.

The treasurer, Gonzalo, has been doing a good job of recordkeeping although he self admits to not being entirely consistent in handing out receipts. They manage a bank account in Acayucan, maintaining a "petty cash" fund within the community. No complaints were presented during the interviews conducted regarding the management of the fund. The fund has been used to purchase light bulbs and small parts such as fuses.

Nine households reported the use of the efficient wood stove in some manner. Two homes use the small stove exclusively, one home uses the small stove as the primary stove with the traditional fogón (three or four stone cooking fire) as the secondary stove, three homes use the stove concurrent with the fogón, one home uses the stove in the city of Acayucan, and two stoves are used intermittently.

2.4 Summary of Part I

One and a half years have passed since the PV systems were installed in the project communities. El Suspiro has embraced the concepts of good governance and has applied the concepts of accountability, transparency and rule of law. Although the tecnicos are not as proactive at the job of maintaining the systems as originally planned, their processes are working well for them and have been adapted to better suit their circumstances. The community has the mechanisms in place and the strength to address issues of non-compliance and non-payment. When presented with operating problems they have the knowledge and confidence to find a solution, albeit perhaps not the most cost-effective solution. The systems are working well and the prospect for sustainability is relatively good.

Arroyo de Caña also has an excellent prognosis for sustainability. The community has issues they must resolve, however the lines of communication are open and they have the organizational structure through which to address them and move forward. They are able to work together to accomplish their goals. They are looking ahead by involving the youth in the process.

Prior to the implementation of this project, Arroyo de Caña had a loosely structured community, defined primarily as those families whose children attend the nearby school. This project brought together diverse elements of the community and provided the mechanism through which they could become a working group with common goals. Initially, a few of the group had been noncommittal and hesitant to participate in the workshop discussions. Some would participate once, but not the next time. As the project activities progressed and the families experienced the gains that may be achieved through working as a team, they pulled together.

For the people of El Suspiro the project enhanced the overall dynamics of the residents. They strengthened their relationship with the municipality which enabled them to expand the services they received. A positive sense of festivity – working towards a common goal – has clearly been a benefit and a learning experience. They have proof that by working together they can achieve bigger and better goals, thus moving the community forward.

Of course for both communities, the electricity provided by the systems gives light when it is dark, extends the productive period of the day beyond the setting sun and brightens the home environment. The solar photovoltaic home lighting systems reduce the health and fire hazards in the home, and the costs associated with fueling lamps. The structure of regularly held meetings establishes a format for dialogue within community. An improved relationship and comfort level with the municipalities was developed through more frequent contact which resulted in additional support provided to communities from both municipalities. The ideas and concepts of starting a community enterprise have been planted and are seeds waiting for the confidence to germinate.

Factors attributable to successes to this point have been the importance of the training provided to the communities at large, specifically the training provided to the committee technicians and the individuals in the leadership positions, and the level of communication within the community itself. They have the confidence and knowledge to use the systems at an optimal level. A structure exists to have a measure of control over how the knowledge is applied. Individuals holding the leadership positions made a difference in the pace at which progress was achieved and how effectively the members of the community interacted. It will be important for the future sustainability of their energy systems and growth of the communities to expand upon their accomplishments and to choose effective leaders to motivate and keep the momentum moving in the forward direction.

During several of the team visits, two members of a nearby community, La Victoria, located about a 20-minute journey by horseback from El Suspiro, participated in our meeting and expressed interest in the project activities.

3. <u>Existing Community Owned Energy Systems – Part II</u>

3.1 Background

There are numerous rural electrification programs throughout the world where utilities, local, state and federal governments, and international agencies provide basic energy systems to households in off-grid communities to power lights, radios or other small electronics. The goal for the respective governments is to provide systems that will simply do the job. Unfortunately, this is a very short-term view. It is short-term since the approach does not address the sustainability or long-term usage of the system itself, or how the system will be maintained or adequately repaired.

Part II of the project encompassed investigating what has and has not worked in terms of energy system governance for existing community-owned and operated energy systems, independent of the technology used, through direct assessments and published information. Site visits and case studies of 14 communities in México, Perú, Nicaragua, and Guatemala were conducted. Framed within a historical and social perspective, the review examined the origins of the systems, current system status, and factors contributing to successes or failures.

3.2 Community Case Studies

Country	State/ Department	Community	Technology
México	Quintana Roo	Xcalak	PV/Wind/Diesel Hybrid
		Punta Allen	Diesel Generator
México	Sonora	Las Zinitas	Distributed Home PV Systems
		Puerto Lobos	
México	Veracruz	Arroyo de Caña	Distributed Home PV Systems
		El Suspiro	
		Juilapa	
		Nuevo Principio	
México	Baja California Sur	Punta Abreojos	Diesel Generator
		Estero La Bocana	Diesel Generator
		Bahía Asunción	Diesel Generator
Perú	Loreto	Padre Cocha	PV/Diesel Hybrid
Guatemala	Quiché	Various	Small Hydro
Nicaragua	Jalapa	Nueva Esperanza	Small Hydro

Table 1. The table above notes the locations with existing community owned and operated systems that were assessed in this review.

In the Mexican state of Quintana Roo the two communities of Xcalak and Punta Allen are very similar in origin, but have progressed to different points in regards to the sustainability of their energy system operations. The economies of both communities were initially agricultural and fishing based economies, which later focused on fishing when disease wiped out the agriculture.

Fishing cooperatives formed and became the central organization for community development, later expanded into the tourism industry.

A view of the community of Punta Allen

Figure 16. Punta Allen

250 kW diesel generator in use in Punta Allen

Figure 17. Diesel system of Punta

The people of Xcalak – members of the fishing cooperative, Andrés Quintana Roo – discuss work plans.

Figure 18. Co-op members in Xcalak

As the population slowly increased and the social dynamics changed with a lower percentage of the population participating in the cooperatives, the municipal government implemented a *delegado* system as the central authority for fee collection and energy system management. The *delegado* (delegate) is elected from the community and by the community; however, the municipality must approve the election results. The delegate attends the general assemblies of the community and reports on the system status, the collection process, and any related issues.

In Punta Allen the fishing cooperative is a strong central authority which transitioned easily to the delegate system. The cooperative has existed for many years and has weathered various crises. The original need for electricity was for lighting to improve quality of life, which then progressed naturally to productive use applications. They now have a successful and sustainable system: they have learned how to manage the administrative processes; they have established rules and procedures; they have negotiated with the municipality to establish a three-tiered tariff structure. Because Punta Allen is a strategically located community for tourism and conservation initiatives, municipal officials are motivated to maintain a positive relationship with the community. Issues related to the community and the cooperative are discussed during regular monthly meetings. The community knows it will never receive the grid extension and thus is motivated to ensure the system stays in good working order.

Under the control of a strong centralized authority for administrative processes, the energy system has been well-managed for years. Such authority has good relations with members of the community and with representatives of the municipal/state/federal government; implements a fair, transparent process for usage and payments; and receives compensation of some kind for the work performed. With this structure, energy systems as well as the administrative transitions required over time are effectively managed.

In Xcalak, the power structure of the community has been divided among six established families which are frequently involved in disputes. Because of this division the population is separated into several factions with little cooperation among them or sense of responsibility to the community as a whole. The individuals elected to be the delegate are often in the middle of a power struggle, impacting their ability to effectively administer the energy system. The result is an energy system that is sometimes well maintained and sometimes neglected, user fees that are sometimes consistently collected and sometimes subject to abuse. Absent the elements of good governance, in this case a consistent set of policies upon which the community has agreed and that are enforced, problems arose that impacted the successful operation of the energy system and which at times proved difficult to overcome.

As the sun sets on this PV-powered home system, is there enough energy stored for nighttime lighting?

Figure 19. Setting sun on PV system

Similar observations were made from the experiences of the Sandia team during the community development project in El Suspiro and Arroyo de Caña, located in the state of Veracruz. Through community-wide organizational meetings and training sessions, governance processes relating to the ownership and management of newly installed photovoltaic home lighting systems were defined and implemented. In one community a strong central leadership, a cohesive sense of community, and effective municipal relations enabled community members to efficiently progress towards the goals leading to sustainable energy and water systems. Conversely, the second community – geographically dispersed, loosely defined and without a strong central authority – labored through this process.

In Nicaragua, the community of Nueva Esperanza selected the members of their governing board with an intentional mix of members of different families so that the leadership of the community was not concentrated within one family. A strong central leader can be a double-edged sword, as the most influential person may actually be intimidating. As important as having a strong leadership structure is, the potential for power to be too concentrated can be problematic. Additionally, in Nueva Esperanza voters make a concerted effort to partner male and female leaders, that is, if the energy board president is a male then the vice president is a female. The rationale is that the female is in the home most of the time and develops the strong ties to the community. This partnering of responsibilities builds in the inclusion of women in a male dominated society and an informal system of checks and balances.

From these examples we summarize that the right mix of individuals in the governing group is an important influence for sustainability, particularly for the leadership positions and the treasurer. The treasurer has the task of being responsible for safeguarding and tracking the financial resources. The characteristics of an effective treasurer will vary depending upon the cultural environment and expectations of the community.

The Mexican state of Baja California Sur is a long peninsula on the west coast of México where fishing and ecotourism are the central economic activities. The region is rich in natural resources from the sea. All along the coast are numerous fishing communities. The team visited Punta Abreojos, Estero La Bocana and Bahía Asunción, communities powered with independent diesel generators managed by cooperatives. The driving need in these locations was the energy requirements for productive use applications; refrigeration and processing for the fishing industry. Over decades and rising from the need and desire to be self-sufficient, co-op members developed the expertise and experience to be independent from outside suppliers.

Punta Abreojos plant provides a centralized power source.

Figure 20. Punta Abreojos

The fishing cooperative is the backbone of the community and holds ultimate authority. It has been a most successful model in this region. Numerous small cooperatives evolved and later merged to form a few larger, centralized co-ops. The administrative structure commonly consists of an elected executive council president (length of term determined by the membership when they vote on by-laws), secretary, treasurer and representatives (vocals). In the case of one of the larger cooperatives, La California, an audit committee oversees the activities of the executive council as well as monitors the observation of fishing limits and quotas. The authority of the cooperative in most every sector of the community is evident. Not only does the cooperative manage the energy sector, but services are expanded to drinking water, medical services and ensuring there an adequate number of teachers and schools. Payment for services is in the form of deductions taken from the proceeds from the fishing catch. These communities had not received much attention from their respective municipalities, thus the circumstances were ripe for the development of such a strong central authority. Now, with the economic stability of the area relatively balanced and the population increasing yet co-op membership proportionally decreasing, the influence and role of the municipal governments is rising, but not unwelcome. The national grid is being extended with technical assistance from the Mexican national power utility (CFE) to standardize service and to address the haphazard manner in which the existing service lines are interconnected. Medical and educational services are also now gradually being assumed by the municipality.

3.3 Business and Administrative Processes

The resources to effectively handle the costs associated with regular maintenance or repairs, the willingness to pay, and the processes in place to direct those resources appropriately are important to sustainability. In two Sonoran communities, Los Zinitas and Puerto Lobos, both fishing based economies under the cooperative structure, inferior system component selection resulted in system failures within the first year. Despite the existence of a good governance structure, the failures occurred before the community was able to acquire enough resources to address the issue and replace parts. Thus, the concept of community ownership was abandoned and the systems converted to individual ownership. As the individual owners lacked the knowledge and finances for proper system usage and maintenance, sustainability was not possible.

Having a tariff in place for operation and maintenance shows seriousness and commitment, but is most effective when there is a perceived service provided in return for the fees. The attitudes of community members towards the notion of system management and willingness to pay differed depending upon the energy technology in use, and whether the energy source was a distributed or centralized source. A correlation exists with the type of technology used to generate electricity and what is perceived to be a worthwhile service in exchange for the fee paid by the user. For example, a diesel generator requires fuel and oil to operate effectively. There is an immediate cause and effect between no fuel and no electricity. The tariff pays for the service of fueling and maintaining a visibly working piece of equipment. Hybrids which combine a diesel generator with another energy generation resource leave a similar impression. Energy systems that are based upon hydro resources require regular daily clearing of the intake channels, and thus a clearly visible service is provided. Wind energy systems are for the most part self-sufficient and have the perception that they require little maintenance; therefore the perceived value of a tariff becomes less evident to the user. With photovoltaic systems there is even less of a perception of an exchange for service provided, especially those systems with low maintenance sealed batteries. Since there are no moving parts, no water to add to the batteries and little visible action taking place, the users aren't convinced of the value of a user fee. Under situations of community diesel systems, even with good governance processes in place, the willingness to pay decreases when the community is connected to a regional grid because of the perception of no service provided for the fees paid.

Determining the tariff structure, i.e. a flat fee where everyone pays the exact same amount versus an actual usage charge, can be a potential source of conflict. In the case of Padre Cocha, Perú, a remote hybrid area power supply that now provides 24-hour electricity to the village located in the Peruvian Amazon region, villagers adjusted the fee structure to address inequities. At first the community tried a flat fee system where every household paid the same amount each month for electricity. This structure soon failed as members observed and complained that one household with a single light bulb paid the same fees as the one with several bulbs and appliances. To resolve the concerns, meters were installed and fees are now collected based on actual usage. Energy consumption consequentially declined as well. This hybrid system is now entirely owned by the community. They must further adjust the fee structure to cover 100% of operation and maintenance costs and to pay for the future cost of battery replacement. Other communities in Perú with small hydro systems usually use a tiered tariff structure based upon consumption.

An example of how a complete lack of any governance and administrative process results in systems that become non-functional after a just a short period of time is found in the community of Nuevo Principio, Veracruz as well as the nearby communities of Juilapa, San Manuel and Emilio Zapata. The communities are very similar to El Suspiro and Arroyo de Caña. For this reason two of the four are included in the case studies for this phase of the project. Although these systems are individually owned rather than owned by the community as an entity, they demonstrate the problems created when governance processes are not addressed.

The team investigated the status of PV systems that were installed in Nuevo Principio two to three years ago, and which were paid for in large part by the Municipality of Acayucan. The users contributed to the cost. After just two years, the majority of the 17 to 18 systems were not operating. At the time of installation no thought was given to helping the people of the community understand how to best use and maintain the systems so that they could continue to provide the energy for lights in the home for many years to come. The users had no idea of the limitations of their systems, how to perform routine maintenance, or who to call if there was a problem. Consequently, the batteries were abused, the controllers were by-passed and some of the panels were sold.

The team met with the local vendor (Antonio Torres Acosta of TECAM Comunicaciones) responsible for the installations of PV home lighting systems in all four communities. From the vendor's perspective all the systems continue to function as designed, however Torres reports that he has not visited the sites recently.

Less than optimal positioning of the PV panel, corroded and dust encrusted batteries, and loose terminal connections were among the conditions found in Juilapa, Veracruz.

Figure 21. Examples of improperly installed and maintained systems

El Suspiro representatives Rubén Vasquez Osorio (ex-president) and Juan Flores Lopez (current treasurer) accompanied the Sandia team to Juilapa, from Acayucan a distance of about 30 minutes travel time over rough dirt road. After visiting Juilapa, representatives from both El Suspiro and Arroyo de Caña will have observed communities outside of their own experience to understand the value of establishing governance processes. The team evaluated a demonstrative sample of 5 of the 14 systems reportedly in Juilapa.

All five systems had 65W pole-mounted panels. In each case the positioned angle of the panels was too steep (at more than 45 degrees, but should have been 20-25 degrees) for the latitude and faced a less than optimal direction. The panels were connected to automobile batteries, which were either almost dead or no longer able to hold a charge. In one home the homeowner was unable to watch TV anymore due to the battery being almost dead. The users understand they will eventually need to replace the battery, but have no specific plan for that purpose. They said they would simply come up with the money in some way. Initially, a committee performed the function of coordinating the process of installation and user cost share. Each system owner paid a cost share of $2,780 (about $278 US) pesos per system. Once the installations took place, the committee disbanded. Among other findings were loose terminal connections, inconsistent or no maintenance, and little understanding of how the system functions in an optimal manner.

The vendor provided basic operational instructions when the systems were installed; however the instructions were not comprehensive. No plan for maintenance was established, no funds set aside for future hardware or support needs, nor does any organizational structure or recourse for problem solving exist. The homeowners knew the vendor was located in Acayucan, however had not seen or been in touch with him since the installation.

Under the conditions observed in Juilapa, the PV systems were minimally functioning and/or in operational decline. Beginning with system design and component selection through organizational planning and administrative structure, the installation process and design lacked the elements that enable sustainability.

During the period between May 1997 and May 1998, eighty-five photovoltaic systems were installed in Puerto Lobos (50) and Las Zinitas (35) as part of a cooperative agreement between the state governments of Arizona (U.S.) and Sonora (Mexico). The sites fluctuate in population since they serve as work centers for fisherman and occasional get-away spots for nearby urban centers.

A core of between 30-50 people lives in each community on a year-round basis. At the time the PV project was initiated the communities reportedly had little organizational structure and no clear leader or central authority. Governance processes were addressed when the systems were installed with an initial cost share required of each user and a monthly maintenance fee to establish an operation and maintenance fund. An in-community technical contact was identified for each community. During the first year several systems in both communities experienced hardware failures of some kind (especially controllers) that were beyond the scope of ability for the technical contact to address. Consequently, the systems were haphazardly repaired by users with limited or no abilities, sold, or simply abandoned. This is an example of the importance of the partnership between good system design, quality hardware and effective governance processes for the sustainability of an energy system.

Many of the homes are constructed of cardboard and/or whatever material can be found.

Haphazard battery connections and cabling with salvaged equipment.

Figure 22. Sonoran PV systems

In Guatemala a review of case studies generally attributes problems impacting sustainability of energy systems to poor system component integration, weak community organization and the lack of sufficient project time to fully incorporate good governance into the process of system installation. At a minimum it is estimated that a period of two and a half to three years from project initiation to completion is optimal to fully incorporate all of the components leading to sustainability. A critical element impacting this is the existence of a rudimentary organizational structure from which to build and implement the governance ideas. Reaching a formal agreement within the governing organization among the users, the community and the governing entity is essential. Follow-up vendor support and involvement beyond the bare basic installation is another component critical to increasing system sustainability, as is the absolute necessity that the technology be integrated into the communities in a manner that is congruent with cultural practices and beliefs.

3.4 Summary of Part II

The following common elements related to the governance leg have been noted in those communities where the systems have been successfully providing electricity:

- A strong central entity in charge;
- An effective mix of individuals in the governing group;
- Planning for future costs;
- A perceived service received for the fees paid;
- A resource to contact in the event of system problems;
- A beneficial relationship with the municipal/state governments;
- Administrative processes in place to manage and control;
- The existence of preliminary organizational structure – for example, communities that have cooperatives for a productive enterprise make excellent candidate communities; and
- Training provided in optimal load management and system operation and maintenance.

Issues for those communities where the systems have ceased to operate in a useful manner include:

- No organizational structure or clear lines of responsibility;
- Minimal training provided for load management, system operation, maintenance and repair;
- Lack of planning for future costs;
- Poorly designed systems with inappropriate components; and
- Lack of vendor presence or nearby technical support.

A centralized power distribution system is a more effective structure than distributed or individually owned energy systems. It is easier to manage and control connection and disconnection activities, in the event of defaults or other concerns, when there is no need to trespass on user property. Centralized electricity distribution systems need meters for every end user. This ensures payment for the amount consumed by each customer and reduces wasted usage. It has been shown in Perú that when user pays a flat rate, there are complaints by low-end users. After pay-per-use meters are installed, then only the high-end users complain – however, the draw on the generator is reduced significantly. This is important in rural communities where they will likely use the same generator for many years, while maintaining incremental growth in consumption.

The planning and saving for a fund to cover future system costs is also more successful where a group collection process with established social ties exists. In a cooperative or other group setting, members of the group are able to monitor and sanction each other in several ways.

4. Considerations and Recommendations

Corresponding to the goals of the Global Village Energy Partnership, which seek to increase access to modern and environmentally sound energy services to improve quality of life, increase economic growth and promote sustainable communities, this project addressed the governance conditions necessary for the successful sustainability of an energy source used to electrify households in rural off-grid villages owning and operating their own energy system. A rural village or community may be able to self-govern, and fund operation and maintenance costs for its own energy system; however, it is uncommon, that a rural village has the available economic resources to purchase its own system. In most cases the government or an international entity makes the donation. After the initial system donation, the village is frequently left to fend for itself to manage the full spectrum of system operation and maintenance. It is possible that the village receives rudimentary operation and maintenance training and perhaps some organizational or governance training, but not to an adequate level and not over a sustained period of time. It is important to commit the necessary amount of time and effort towards design and capacity building; ideally a period of at least two years with an extended follow-up program.

Project sponsors employ various approaches to bring energy to rural villages in general. Any perception by a particular village that the main utility grid will be extended increases the tendency for the village to avoid the effort necessary to obtain and manage a proprietary system. There are many examples of rural off-grid energy project beneficiaries that initially met project site selection criteria, but shortly after acquiring their systems, received energy service from a grid extension. At first glance, this scenario appears to have been a lack of due diligence in the site selection process; however, it is more likely the result of an increased awareness and discussion of the possibilities of electrification, and increased interaction and communication with government representatives.

Community-based ownership of energy systems has significant advantages over individual ownership. Solar home lighting systems are distributed in nature, thus harder for a community to control than a centralized system. Should the end user default in a centralized system, the line is disconnected at the street. However, with a distributed system located on the user's property, disconnecting or removing requires trespassing.

Centralized electricity distribution systems should also have meters for every end user. This ensures payment for the amount consumed by each customer and reduces waste. It has been shown in Perú that when everyone pays a flat rate, low-end users complain. After pay-per-use meters are installed, then only the high end users complain – however, the result is that the draw on the generator is reduced significantly. This is important in rural communities where they will likely use the same generator for many years, while maintaining incremental growth in consumption.

Willingness to pay is directly related to perceived service and the value of the service. Where users recognize a direct connection between high maintenance energy systems such as diesel and the availability of electricity in the homes each day, there is a high willingness to pay (see pages 31 and 32). At the other end of the scale there are the solar home lighting systems with maintenance-free batteries. The end users benefit from the service, but do not see or hear any apparent activity and do not recognize the value of a user fee.

Regardless of the technology used, for any energy project to be successful, an in-country partner is crucial when working in culturally diverse environments. Any grassroots good governance project absolutely requires an in-country, in-region partner intimately familiar with the local culture (social, language, history, politics, etc.). Such a working partnership, perhaps on a regional basis, can maintain a presence that is within reach, to nurture the organizational and governance efforts over a substantial time period. Similarly, a no-cost direct-line communication with a technical advisor for longer term assistance is beneficial as well.

It is important to understand the existing organizational structure of the community in order to effectively deploy good governance practices. Structure provides a framework for the sustainability of a community organization. The communities in Veracruz have a western-type of structure which allowed for smooth progression to a system of elected officials. Inherent in a successful structure is the care with which selecting the responsible individuals should be taken, especially the selection of the treasurer (see page 30). A democratic structure with built-in checks and balances reduces the possibility of one single individual assuming control. However, if the communities were, for example, indigenous – as in area of Chiapas – then one would have to understand and incorporate the concept of the elders and consensus-based decisions. It would be a more daunting task to work with the latter.

In general, solar home lighting systems (100W or less) provide sufficient power for a few efficient lamps and a small radio or television. Solar home lighting systems are popular with governmental social programs and do replace the use of small appliance throwaway batteries and kerosene fuel lamps. Although not suitable for poverty alleviation through productive applications, they are associated with popular rural electrification programs. They are not powerful enough for productive applications. Due to the large-scale implementation of such systems, technical assistance is extremely important to those purchasing and installing systems. A rural electrification program with poverty alleviation as a central theme should envision productive applications before general household electrification.

Photovoltaic system components (energy source) are advancing towards plug-n-play, but have not yet reached a mature point – especially when coupled with rural applications in the developing world and the use of appliances principally designed for a different energy infrastructure. Special attention must be paid to the selection of system components, energy efficient loading, and how all will be used together.

Solar home systems for the rural off-grid regions of the developing world should be designed to use only DC loads or appliances. Sole use of DC loads would reduce additional system energy losses, maximize reliability, and avoid the temptation to connect power-hungry consumer appliances to the system. PV modules and batteries already function in the DC mode. An inverter (DC to AC) is required to power AC appliances. Inverters add a loss to the system together with the appliances – which usually function on DC voltages – but add more components (AC to DC converter) for convenience to connect to an AC outlet. Needless to say the added components reduce overall reliability and the AC outlet invites the purchase of additional household items not appropriate for the system as designed.

The focus of this project was on governance rather than energy. Grassroots governance efforts at the community level empower the community to cope with all community concerns: water, education, health, energy, etc. It also improves the community's ability to effectively interact with higher bodies of government. The three principals, or the legs of the table of sustainability, apply to community owned and operated systems that have inherent technological components such as those generating electricity, and pumping, purifying and delivering water. A village cooperative might follow the administrative principals affiliated with good governance, but not necessarily the other principals, unless the cooperative depends on a technological investment.

Good governance can never be fully achieved if the community does not have a real interest in, or does not perceive a value for, what is being presented. For example, in this project the team's intent was to install centralized systems for productive applications; a traditional application of technology for rural community development. The team described the concepts of renewable energy applications to the villagers, which included a centralized energy system for productive use in a community center setting. The villagers discussed the options, as well as other ideas, among themselves. Then, *they* decided their needs would be better met with smaller individual systems at their homes, instead of a larger shared one within their community. In this case they were motivated to contribute to the overall costs from their own savings and willing to negotiate with the municipality for additional funds. It was the first step towards good governance on the path to sustainability.

The legs supporting the *Table of Sustainability* for energy systems in rural communities are:

- Robust system design and quality components;
- Proper operation, maintenance and repair; and
- Effective administration and governance.

By concentrating not only on the legs of the *table*, but also on the lateral segments of knowledge and communication that bind the legs together, sustainability can be achieved.

Of course incorporating the components of sustainability consumes time, energy, and funding, and with a limited amount of money fewer homes might receive systems. However, the more effort that is expended towards implementing the elements that support sustainability, the more successful and cost effective the projects will be in the long run.

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Sandia National Laboratories: México Renewable Energy Program. http://www.re.sandia.gov.

Appendices

Appendix A – Travel Dates and Trip Purpose

July 28-August 02, 2003: Project initiation and planning meetings with FIRCO, Sandia National Laboratories and USAID/México, México City.

September 25-October 04, 2003: Collaborative planning and site selection meetings with FIRCO and USAID/México together with Mexican governmental agency stakeholders for community renewable energy projects in México--SENER, SEDESOL, CDI, CONAE, FUNDENERG and MREP, México City.

February 02-February 05, 2004: Site visits to Veracruz.

March 01-March 04, 2004: Orientation and introductory workshops with community members, El Suspiro and Arroyo de Caña, Veracruz.

March 27-April 02, 2004: Governance and administrative practices and technical training activities, El Suspiro and Arroyo de Caña, Veracruz.

April 18-April 25, 2004: Preparations for the PV system training and installation; Workshops on the construction and benefits of the efficient wood stove, El Suspiro and Arroyo de Caña, Veracruz.

June 13-June 22, 2004: System installation and training, El Suspiro; Finalize system options, Arroyo de Caña, Veracruz.

July 2004: Community assessment site visit, Punta Allen and Xcalak, Quintana Roo.

August 16-August 22, 2004: System installation and training, Arroyo de Caña; Follow-up operation, maintenance and administrative training in El Suspiro, Veracruz.

October 2004: Community assessment site visit, Las Zinitas and Puerto Lobos, Sonora.

November 16-November 17, 2004: Community assessment site visit, Padre Cocha, Perú (travel costs leveraged by another project).

December 01-December 05, 2004: Follow-up technical and administrative training, El Suspiro and Arroyo de Caña, Veracruz.

February 17-February 23, 2005: Survey of El Suspiro and Arroyo de Caña, Veracruz.

March 2005: Community assessment site visits, Punta Abreojos, Estero La Bocana, Bahía Asunción, Baja California Sur.

December 02-December 08, 2005: Final evaluation and survey, Arroyo de Caña and El Suspiro, Veracruz.

Appendix B – Primary Family Heads

Arroyo de Caña

1. Guillermo Martínez Feliciano, Community Leader
2. Rodolfo de Jesús Martinez Candelaria
3. Juan Herrera Ruperto
4. Juana Vidal Cruz
5. Cleto Arias Cortés
6. Alfredo Santos Vidal
7. Enrique Santos Vidal
8. Agustino Herrera Sainz
9. Gonzalo Herrera Escrivano
10. Felipe Domínguez Juárez
11. Marcelino Anastasio Suriano
12. Moisés Erias Julián
13. Artemio Arias Cortés
14. Alvino Cruz Rosas
15. Tomás Cruz Rosas
16. Sofía Juliana Leonardo
17. José Herrera Ruperto
18. Arturo Ramón García

El Suspiro

1. Rueben Vásquez Osorio, Community Leader
2. Andrés Espinosa López
3. Alfonso Joachim Silva
4. Benjamín Flores Capto
5. Flavio Reyes Vásquez
6. Pedro Jaime Domínguez
7. Julio Aguilera Vera
8. Adolfo Beltrán Cruz
9. Genaro Flores López
10. Juan Flores López
11. Simón Conde Arroyo
12. Agustina Morrugares Domínguez

Appendix C – Community Agreements (Original Versions)

La Comunidad de Arroyo de Caña

Acta de Acuerdo

La comunidad Arroyo de Caña representada por cada jefe de familia y reunidos en asamblea para discutir la forma de gobierno de sistema de energía eléctrica a base de sistemas solares llegan a los siguientes acuerdos firmando al calce los que participaron en dicho acto.

<u>1. Sobre la propiedad de los sistemas:</u>

1.1 El propietario de los sistemas de energía fotovoltaica es la comunidad y cada una de las familias de la comunidad es el usufructuario mientras viva en Arroyo de Caña.
1.2 Cada familia participante debe pagar una cuota de inscripción de $400 pesos, con el que se formara un fondo para mantenimiento de los sistemas.
1.3 Cuando una familia se mueve de la comunidad, el sistema quedará en la comunidad.
1.4 Cuando una familia se mueve a la comunidad, y si hay un sistema disponible, podrá tener un sistema de energía fotovoltaica pagando su cuota de inscripción.

<u>2. Sobre el comité de administración y mantenimiento de los sistemas:</u>

2.1 La comunidad nombra a un comité, quien será responsable de sistema de Bombeo de Agua y Luz Solar.
2.2 Las personas que forman el comité permanecerán en el puesto por un año, pasado este periodo, la asamblea nombrara a un nuevo grupo de personas que formaran el nuevo comité.
2.3 Si el comité no cumple con sus responsabilidades, la asamblea podrá removerlos de su puesto antes de que termine el año de gestión.
2.4 Para que un elemento de comité se retire su puesto deberá ser autorizado por la asamblea.
2.5 El comité tiene la obligación de aprender todo lo relativo a los sistemas de energía, informar a la comunidad sobre aspectos técnicos y administrativos, planear y organizar las reuniones mensuales de la asamblea, hacer recomendaciones a los usuarios sobre la forma correcta de operación de los sistemas e implementar las decisiones que la asamblea tome.

<u>3. El Comité de Bombeo de Agua y de Luz Solar consiste de las siguientes posiciones y responsabilidades:</u>

3.1 Presidente: El Presidente tiene autoridad y responsabilidad de que el comité lleve a cabo las tareas que le son asignadas. El presidente es el representante de la comunidad frente a cualquier autoridad municipal.
3.2 Secretario: El Secretario tiene responsabilidad de notificar a la comunidad las fechas de las reuniones. También tiene responsabilidad de levantar las actas de cada reunión y de hacer un reporte sumario sobre los actividades y acuerdas de cada reunión.
3.3 Tesorero: El Tesorero tiene responsabilidad de administrar los fondos de la comunidad. Incluye la colección de los fondos, un registro de las contribuciones, y un reporte de cuentas para presentar a la comunidad en cada reunión.

3.4 Técnicos: Los Técnicos tienen las responsabilidades de aprender toda la información técnica sobre los sistemas, mantener los sistemas apropiadamente y capacitar a los usuarios como mantener los sistemas y el uso apropiado de los aparatos. Incluye inspecciones mensuales de cada sistema, especialmente las baterías, asegurando que tienen agua suficiente y que todo esta operando correctamente y de forma eficiente.

4. De las reuniones de asamblea:

4.1 La comunidad tendrá asamblea el último sábado de cada mes. Si El Presidente tiene que cambiar la fecha, se notifica a la comunidad la nueva fecha.
4.2 Una representante de cada familia debe estar presente; si no hay un representante debe pagar una multa de $50 pesos.
4.3 Entre los objetivos de la reunión se debe incluirlos reportes de las cuentas monetarias, las actas de reuniones anteriores y el diálogo sobre cualesquier pregunta o problema relativo a los sistemas de energía o bombeo de agua.

5. De los fondos para el mantenimiento:

5.1 El fondo de mantenimiento requiere de una contribución de $25 pesos por mes por usuario, pagado por el representante de cada familia en la asamblea.
5.2 Ese fondo es propiedad y para beneficio de la comunidad para ahorrar dinero en caso de reparaciones, para reemplazar partes necesarias en el futuro, o para cualquier otro uso en relación a los sistemas que decida el comité y la asamblea.
5.3 Si el usuario no paga su contribución después de dos meses, el sistema regresara al comité para su resguardo y se le entregará nuevamente cuando el usuario moroso pague sus cuotas vencidas.

Nombre	Sistema #	Firma
La Escuela	01	
Alfredo Santos Vidal	02	
Enrique Santos Vidal	03	
Juana Vidal Cruz	04	
Cleto Aria Cortes	05	
Gonzalo Herrera Escribano	06	
Rigo Nolasco Ruperto	07	
José Herrera Ruperto	08	
Fernando Herrera Ruperto	09	
Juan Herrera Ruperto	10	
Agustino Herrera Sainz	11	
Guillermo Martínez Feliciano	12	
Rodolfo de Jesús Martínez Candelaria	13	
Felipe Domínguez Juárez	14	
Moisés Erias Julián	15	
Sofía Julián Leonardo	16	
Bartolo Eria Domínguez	17	
Alvino Cruz Rosas	18	
Tomas Cruz Rosas	19	
Rafael Betanso Valdivieso	20	
Marcelino Anastasio Suriano	21	

La Comunidad de El Suspiro

Acta de Acuerdo

La comunidad El Suspiro representada por cada jefe de familia y reunidos en asamblea para discutir la forma de gobierno de sistema de energía eléctrica a base de sistemas solares llegan a los siguientes acuerdos firmando al calce los que participaron en dicho acto.

<u>1. Sobre la propiedad de los sistemas:</u>

1.1 El propietario de los sistemas de energía fotovoltaica es la comunidad y cada una de las familias de la comunidad es el usufructuario mientras viva en El Suspiro.
1.2 Cada familia participante debe pagar una cuota de inscripción de $500 pesos, con el que se formara un fondo para mantenimiento de los sistemas.
1.3 Cuando una familia se mueve de la comunidad, el sistema quedará en la comunidad.
1.4 Cuando una familia se mueve a la comunidad, y si hay un sistema disponible, podrá tener un sistema de energía fotovoltaica pagando su cuota de inscripción.

<u>2. Sobre el comité de administración y mantenimiento de los sistemas:</u>

2.1 La comunidad nombra a un comité, quien será responsable de sistema de Bombeo de Agua y Luz Solar.
2.2 Las personas que forman el comité permanecerán en el puesto por un año, pasado este periodo, la asamblea nombrara a un nuevo grupo de personas que formaran el nuevo comité.
2.3 Si el comité no cumple con sus responsabilidades, la asamblea podrá removerlos de su puesto antes de que termine el año de gestión.
2.4 Para que un elemento de comité se retire su puesto deberá ser autorizado por la asamblea.
2.5 El comité tiene la obligación de aprender todo lo relativo a los sistemas de energía, informar a la comunidad sobre aspectos tecnicos y administrativos, planear y organizar las reuniones mensuales de la asamblea, hacer recomendaciones a los usuarios sobre la forma correcta de operación de los sistemas e implementar las decisiones que la asamblea tome.

<u>3. El Comité de Bombeo de Agua y de Luz Solar consiste de las siguientes posiciones y responsabilidades:</u>

3.1 Presidente: El Presidente tiene autoridad y responsabilidad de que el comité lleve a cabo las tareas que le son asignadas. El presidente es el representante de la comunidad frente a cualquier autoridad municipal.
3.2 Secretario: El Secretario tiene responsabilidad de notificar a la comunidad las fechas de las reuniones. También tiene responsabilidad de levantar las actas de cada reunión y de hacer un reporte sumario sobre los actividades y acuerdos de cada reunión.
3.3 Tesorero: El Tesorero tiene responsabilidad de administrar los fondos de la comunidad. Incluye la colección de los fondos, un registro de las contribuciones, y un reporte de cuentas para presentar a la comunidad en cada reunión.
3.4 Técnicos: Los Técnicos tienen las responsabilidades de aprender toda la información técnica sobre los sistemas, mantener los sistemas apropiadamente y capacitar a los usuarios como mantener los sistemas y el uso apropiado de los aparatos. Incluye inspecciones mensuales de

cada sistema, especialmente las baterías, asegurando que tienen agua suficiente y que todo esta operando correctamente y de forma eficiente.

4. De las reuniones de asamblea:

4.1 La comunidad tendrá asamblea el último domingo de cada mes.
4.2 Una representante de cada familia debe estar presente; si no hay un representante debe pagar una multa de $50 pesos.
4.3 Entre los objetivos de la reunión se debe incluirlos reportes de las cuentas monetarias, las actas de reuniones anteriores y el diálogo sobre cualesquier pregunta o problema relativo a los sistemas de energía o bombeo de agua.

5. De los fondos para el mantenimiento:

5.1 El fondo de mantenimiento requiere de una contribución de $30 pesos por mes por usuario, pagado por el representante de cada familia en la asamblea.
5.2 Ese fondo es propiedad y para beneficio de la comunidad para ahorrar dinero en caso de reparaciones, para reemplazar partes necesarias en el futuro, o para cualquier otro uso en relación a los sistemas que decida el comité y la asamblea.
5.3 Si el usuario no paga su contribución después de dos meses, el sistema regresara al comité para su resguardo y se le entregará nuevamente cuando el usuario moroso pague sus cuotas vencidas.

Nombre	Sistema #	Firma
La Escuela	01	
Iglesia	02	
Pedro Jaime Domínguez	03	
Andrés Espinosa López	04	
Alfonso Joachin Silva	05	
Simón Conde Arroyo	06	
Rubén Vázquez Osorio	07	
Genaro Flores López	08	
Benjamín Flores Capto	09	
Juan Flores López	10	
Julio Aguilera Vera	11	
Octavio Reyes Vásquez	12	
Adolfo Beltrán Cruz	13	

Appendix D – Technical Details of Solar Home Lighting Systems

Design specifications were developed for two configurations, referred to as System A (75W) and System B (100W). System A, the basic design, was the smaller system in terms of solar module input and battery capacity. It was also a DC-only system, thus requiring that all loads operate on DC voltage. System B was an upgrade to a larger solar and battery capacity, and included a DC to AC converter to handle small AC-only loads or appliances, in addition to the standard DC loads. The following is a list of components for Systems A and B, with the items noted in blue font representing differences between the two configurations:

Components

<u>System A (75W)</u>

One Condumex IEM Model CX-75 solar module, 75W, mono-crystalline
One Trojan Model 27TMX deep-cycle battery, flooded lead acid, 12v, 105Ah capacity
One Xantrex (Trace) Model C-12 charge/load controller
Three DC fluorescent lamps (two 13W and one 20W) with ballast and reflector plate
One protector cage to house the battery
Cable (12-gauge between module and batteries; 14-gauge to loads)
Switches (one for each lamp)
Hardware (terminals, screws, connectors, pole, module support, fuses, grounding rod)

<u>System B (100W)</u>

Two Condumex IEM Model CX-50 solar modules, 50W (100W total), mono-crystalline
Two Trojan Model T-105 deep-cycle batteries, flooded lead acid, 6v (12v total), 220Ah capacity
One Samlex-America Model SI-400 inverter, 400W maximum
One Xantrex (Trace) Model C-12 charge/load controller
Three DC fluorescent lamps (two 13W and one 20W) with ballast and reflector plate
One protector cage to house the battery
Cable (12-gauge between module and batteries; 14-gauge to loads)
Switches (one for each lamp)
Hardware (terminals, screws, connectors, pole, module support, fuses, grounding rod)

Design Details

The annual average solar irradiance in the southern Veracruz region has been estimated to be 4.5 sun-hours. Thus, in one average day a 100W PV array would be able to output 450 watt-hours (Wh) of power. Assuming a battery efficiency of 80%, 360Wh would be available in storage. In a 12-volt system, 37.5 ampere-hours (Ah) would charge the battery. The DC loads for lighting amount to 46W in total, thus a day's worth of average sunshine into the battery can power the lights for 7 hours at night or 1 hour each night for 7 nights. Under a typical system usage pattern, not all lights are used at the same time. Small radios and/or televisions are frequently used in lieu of lights. Operating the television at night serves as a source of lighting as well.

The battery in the 100W system has a capacity of 220Ah. At full charge it can power lights for about 6 days to reach an 80% battery discharge. Under conditions of normal daily usage, the rate of discharge would be about 20% per day with an easy charge to full capacity the next day. At this cycling rate the batteries should last a good 5 to 7 years, provided the water levels of the battery cells are maintained.

For the 75W systems, an average solar day would produce 337.5Wh which would mean 270Wh available in storage. There would be 28Ah going into the battery each average day. The lights could be used a little more than 5 hours each day or 1 hour for 5 days. The battery has a capacity of 105Ah. An evening of 6 hours under full lighting conditions would use 22Ah of electricity or 20% discharge of the battery. The battery would be fully charged the next day with 28Ah available.

The latitude of southern Veracruz is 18 degrees. The vendor provided a solar module fixed tilt angle of 25 degrees, very close to optimal.

All systems had a Xantrex C-12 charge/load controller. This model was chosen due to its adjustable High Voltage Disconnect (HVD) which can be set to an optimal level to fully charge the flooded lead acid batteries. Other models have fixed levels that are too low (according to battery experts) for the application – PV charging systems. Settings for the controllers were:

High Voltage Disconnect: 14.8v
High Voltage Reconnect: 14.5v
Low Voltage Disconnect: 11.5v
Low Voltage Reconnect: 13.0v
Auto Reconnect after Low Voltage Disconnect: ON

The main purpose of a controller is to manage and protect the battery. It manages input from the PV modules to the batteries and output from the batteries to the loads. The multi-colored Light Emitting Diode (LED) signals the state of the control cycle and the voltage condition of the battery. The LED is a great visual indicator to the end-user to determine the status of the system. The C-12 has been available for many years and has a good track record. It has all of the necessary protections (e.g. over-temperature, electronic overload, short circuit) to make it a robust component.

Flooded lead acid batteries (ones that require the regular addition of water) were selected for this project because they are cheaper, hardier, and because of the very fact they need to be watered need to add water. The latter was an important factor in the governance aspect of the project. The batteries are deep-cycle as opposed to shallow-cycle automobile batteries, thus they can be discharged by 80% and then recover when charged. Trojan batteries were selected based on test results and their track record for use in PV systems. The 6v battery in System A is actually designed for forklifts. The 12v battery in System B is designed for marine applications.

A 400W inverter was a component of the larger system, allowing the system to power both AC and DC loads. End-users had identified the requirement to be able to operate blenders for short intervals of time and to have the option of using an AC plug for a radio or small television. This prompted the addition of the inverter and the increase in system capacity. The end-users paid for this system upgrade and were educated on the shortcomings of using the inverter.

Although DC blenders are made for the recreational vehicle market, they were not found in the marketplaces of Veracruz. Therefore, the AC model had to be considered as the only option. Most have motors that require 300W of power; hence the 400W inverter was selected. Fortunately, the use of a blender is only for several seconds on any given day.

The inverter chosen is typical of automobile applications where the unit is plugged into the cigarette lighter to connect to the battery. There are three shortcomings of this type of inverter to be used in rural PV systems: 1) it is designed for relatively clean environments; 2) it connects directly to the battery (outside of the controller's protection) and 3) it has a low-voltage disconnect at 10.5v (controller is set to 11.5v).

A terminal block was added to the systems for distribution of DC lines to additional loads. Most radios, for example, are modified to run off a 12v battery. The block made it easier to connect to this type of load.

Appendix E – FIRCO Document El Suspiro

SECRETARIA DE AGRICULTURA, GANADERÍA, DESARROLLO RURAL, PESCA Y ALIMENTACIÓN

DELEGACIÓN ESTATAL VERACRUZ

SECRETARÍA DE DESARROLLO AGROPECUARIO RURAL, FORESTAL, PESCA Y ALIMENTACION DEL GOBIERNO DEL ESTADO DE VERACRUZ

FIDEICOMISO DE RIESGO COMPARTIDO

GERENCIA ESTATAL VERACRUZ

AGENCIA INTENACIONAL PARA EL DESARROLLO DE LOS ESTADOS UNIDOS (USAID)

LABORATORIOS NACIONALES SANDIA

ALIANZA PARA EL CAMPO

PROGRAMA DE FOMENTO GANADERO

PROYECTO DE ENERGIA RENOVABLE

PARA EL DESARROLLO RURAL

PROYECTO PRODUCTIVO EN EL
CENTRO DE DESARROLLO COMUNITARIO

"EL SUSPIRO"

EL SUSPIRO, MPIO. SAYULA DE ALEMÁN, VER.
MICROCUENCA "EL NARANJO"

ELECTRIFICACIÓN EN AULA ESCOLAR, GALERA PARA POLLOS Y VIVIENDAS Y BOMBEO DE AGUA PARA ABREVADERO Y HORTALIZA FAMILIAR

CON EL USO DE ENERGÍA FOTOVOLTAICA

Xalapa, Ver., Septiembre de 2003.

CENTRO DE DESARROLLO COMUNITARIO, “EL SUSPIRO”

EL SUSPIRO, MPIO. SAYULA DE ALEMÁN, VER.

CONTENIDO

1. Solicitud
- 1.1. Solicitud
- 1.2. Identificacion oficial y CURP de productor y beneficiarios.
- 1.3. Constancia que acredite actividad pecuaria.
- 1.4. Certificado parcelario y/o escritura de propiedad

2. Datos generales del Centro de Desarrollo Comunitario
- 2.1. Nombre del Centro de Desarrollo Comunitario
- 2.2. Representante y relación de beneficiarios
- 2.3. Localidad
- 2.4. Municipio
- 2.5. Croquis de localización y ubicación geográfica
- 2.6. Distancia a la red eléctrica (deberá ser mayor de 1 km)

3. Aspectos sociales
- 3.1. Población
- 3.2. Vivienda
- 3.3. Alimentación
- 3.4. Salud
- 3.5. Servicios públicos
- 3.6. Educación
- 3.7. Recreación y Religión
- 3.8. Organización

4. Aspectos físicos y económicos del Centro de Desarrollo Comunitario
- 4.1. Climatología y recurso solar
- 4.2. Recursos hidráulicos
- 4.3. Fuente de abastecimiento
- 4.4. Infraestructura existente (inventario y valor)
- 4.5. Maquinaria y equipo (inventario y valor)
- 4.6. Superficie total (agrícola, ganadera, forestal)
- 4.7. Tipo de tenencia de la tierra
- 4.8. Uso actual del suelo
- 4.9. Ganadería
  - 4.9.1. Inventario ganadero
  - 4.9.2. Tipo de ganadería
  - 4.9.3. Composición del hato
  - 4.9.4. Prácticas desarrolladas en el manejo del hato y la pradera
  - 4.9.5. Capacidad de carga
  - 4.9.6. Producción actual de la explotación
  - 4.9.7. Costos de producción
  - 4.9.8. Valor de la producción
  - 4.9.9. Utilidad

4.10. Agricultura
  4.10.1. Inventario agrícola
  4.10.2. Tipo de agricultura
  4.10.3. Producción actual de la explotación
  4.10.4. Costos de producción
  4.10.5. Valor de la producción

4.11. Situación económica, créditos vigentes y adeudos.
4.12. Problemática

5. Estudios Técnicos
5.1. Estudio Topográfico (desnivel entre la fuente de agua y el tanque de almacenamiento)
5.2. Evaluación de la fuente de agua (producción diaria de agua en litros/minuto)

6. Proyecto
6.1. Justificación
6.2. Acciones a desarrollar
6.3. Iluminación en viviendas, aula escolar y galera de cerdos
  6.3.1. Cálculo las demandas energéticas
6.4. Bombeo de agua
  6.4.1. Cálculo de la demanda de agua
  6.4.2. Cargas hidráulicas
  6.4.3. Ubicación de la descarga
  6.4.4. Planeación de las líneas de conducción y distribución, tanque de almacenamiento
6.5. Diseño de los sistemas fotovoltáicos
  6.5.1. Dimensionamiento de arreglos fotovoltáicos y criterios de selección de equipos
  6.5.2. Esquema de los arreglos
  6.5.3. Catálogo de conceptos, presupuesto y especificaciones técnicas
6.6. Producción esperada agrícola y ganadera
6.7. Costos de producción estimados agrícola y ganadera
6.8. Valor de la producción esperada agrícola y ganadera
6.9. Estructura de aportaciones
6.10. Período de ejecución de las acciones

7. ANEXOS.
7.1. Cuadro de cotizaciones, lista de precios de los materiales, equipos y piezas especiales; garantías y especificaciones del fabricante
7.2. Reporte de clima y recurso solar de la zona

CENTRO DE DESARROLLO COMUNITARIO, “EL SUSPIRO”

EL SUSPIRO, MPIO. SAYULA DE ALEMÁN, VER.

CONTENIDO

1. Solicitud

1.1 Solicitud
1.2 Identificación oficial y CURP de productor y beneficiarios.
1.3 Constancia que acredite actividad pecuaria.
1.4 Certificados parcelarios y/o escrituras de propiedad

2. Datos generales del Centro de Desarrollo Comunitario

2.1 Nombre del Centro de Desarrollo Comunitario: El Suspiro
2.2 Representante y relación de beneficiarios: Rubén Vazquez osorio
Simón Conde Arroyo
Pedro Jaime Dominguez
Benjamín Flores Copto
Octavio Reyes Vazquez
Juan Flores López
Genaro Flores López
María Rangel Valentín
María Pavón Chiquito
Mariana Flores López

2.3 Localidad: El Suspiro

2.4 Municipio: Sayula de Alemán

2.5 Croquis de localización y ubicación geográfica:
El Proyecto Productivo esta ubicado de acuerdo a la carta estatal de regionalización fisiográfica y pertenece a la llanura costera del golfo sur, Provincia V y subprovincia 1 de la llanura costera Veracruzana, donde se presenta el sistema de topoformas tipo lomerío. Se ubica en la región hidrológica RH29 en la cuenca hidrológica B longitud 94º 51' 50" y latitud 17º 37' 39"´a 40 msnm.

El sitio del proyecto se ubica en la localidad El Suspiro. Desde la Cd. de Sayula de Alemán se recorren 40 km de terracería accesible durante todo el año; primero se recorren 20 km por la carretera estatal con dirección a Jesús Carranza hasta la comunidad de Campo Nuevo, perteneciente al municipio de San Juan Evangelista, posteriormente, a la izquierda y 20 km de terracería hasta llegar a lugar del proyecto, pasando por Medias Aguas, El Refugio, El Oriente, La Florida y Romero Rubio.

2.6 Distancia a la red eléctrica: En la comunidad de El Suspiro, no se cuenta con el servicio de energía eléctrica, la distancia más corta a la red de la Comisión Federal de Electricidad es 4 km, en la comunidad de Romero Rubio, sin posibilidad de extenderse a las inmediaciones de la localidad. Esta situación hace viable la instalación del proyecto.

3. Aspectos sociales

3.1 Población: 55 habitantes.

3.2 Vivienda: Existen 11 viviendas con paredes de adobe (bambú y arcilla) con techumbre de palma, sin letrinas.

3.3 Alimentación: Su alimentación es a base de tortillas de maíz, frijoles, huevos y en algunos fines de semana carne de pollo o cerdo.

3.4 Salud: No se cuenta con instalaciones de instituciones de seguridad social, en caso de requerir atención médica los habitantes acuden al municipio de Sayula de Alemán, Ver. Las enfermedades más comunes que ocasionalmente se presentan en la población son: gripas e infecciones gastrointestinales.

3.5 Servicios públicos: El único servicio público con que cuenta la comunidad es un salón escolar, atendida por maestros CONAFE. El acceso a la comunidad es por terracería y no tienen servicio de transporte.

3.6 Educación: Actualmente acuden a un salón escolar de la comunidad 20 niños a cursar la educación primaria por maestros del CONAFE.

3.7 Recreación y Religión: Las principales festividades de la comunidad son la Semana Santa, Día de muertos, Navidad y Fiestas patronales; profesan 3 religiones, que de acuerdo al orden de religiosos es la Católica, Evangélica y Sabática. En la comunidad solo existe una capilla para los Sabáticos.

3.8 Organización: La principal organización se basa en las costumbres y tradiciones. Actualmente están organizados en un comité pro-electrificación cuya función principal es solicitar apoyo a las autoridades municipales para la implementación de "plantas solares".

4. Aspectos físicos y económicos del Centro de Desarrollo Comunitario

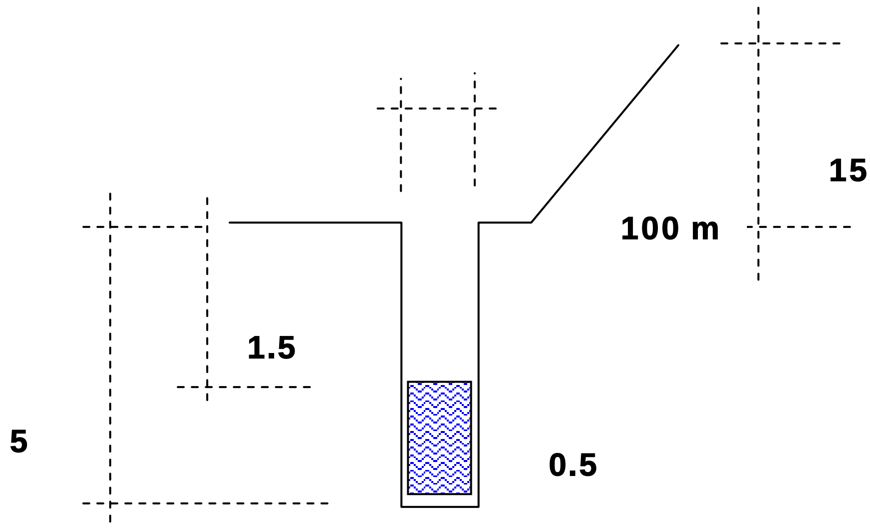
4.1 Climatología y recurso solar: predomina un clima cálido subhúmedo con lluvias en verano y cuenta con un período de canícula

La precipitación total presente en la microregión es de 1803.8 mm anuales, con una máxima de 655.7 mm en el mes de junio y una mínima de 0. mm en el mes de abril. La evaporación anual es del orden de 1396.6 mm. La temperatura media anual es de 25.6 ºC.

El número de días nublados cerrados es de 113, el número de días no niebla es de 39.94 y el número de días con lluvias apreciables es el 132.
Estos datos fueron tomados de la estación Acayucan de Acayucan, Ver. en un período de observación de 30 años (1951-1980).

4.2 Recursos hidráulicos: La unidad de Producción se ubica en la cuenca hidrológica del Coatzacoalcos.

4.3 Fuente de abastecimiento: Las necesidades de agua del centro comunitario se abastecen de norias ubicadas en cada una de las parcelas; sin embargo en la implementación del presente proyecto la noria considerada se ubica a 100 metros en la parcela de uno de los productores. La noria tiene las siguientes características: Ademe de mampostería de blocks con 1.0 metros de diámetro, profundidad de 6.5 m, el nivel estático se ubica a 1.5 metros y el nivel dinámico a 2.0 metros. La producción de agua de la fuente en estiaje es 2.6 m3/hr.



4.4 Infraestructura existente (inventario y valor): La infraestructura con que cuentan es la casa en donde habita cada una de las familias que conforman la población El Suspiro, la fuente de agua en cada una de las parcelas ejidales y algunos cercos con alambre de púas. Existe un corral rústico.

4.5 Maquinaria y equipo: Cuentan con herramienta menor: machetes, limas, azadones.

4.6 Superficie total (agrícola, ganadera, forestal): La comunidad se compone de 80 ha dedicadas principalmente a la ganadería, 65 has; 6 has para la siembra de maíz para autoconsumo, 7 has de monte y 2 has pertenecientes al centro de desarrollo comunitario.

4.7 Tipo de tenencia de la tierra: Se encuentran bajo el régimen jurídico ejidal dentro de la localidad El Suspiro.

4.8 Uso actual del suelo: Agostadero, agricultura de básicos para autoconsumo y forestal.

Ganadería

4.8.1 Inventario ganadero: El inventario ganadero asciende a un total de 80 cabezas de ganado bovino, 5 equinos, 40 ovinos y 30 aves.

4.8.2 Tipo de ganadería El tipo de ganadería bovina es el de doble propósito, tanto en ovinos como bovinos es en forma extensiva y aves de traspatio.

4.8.3 Composición del hato: El en caso del ganado bovino, corresponden a 35 vacas, 25 becerros, 3 sementales y 17 novillonas. En los ovinos, corresponden a 2 sementales, 18 borregas y 20 borregos. Correspondiendo en el caso del ganado bovino y equino un equivalente a 52 U.A., en el caso de los ovinos un equivalente 8 U.A.

4.8.4 Prácticas desarrolladas en el manejo del hato y la pradera: Por el tipo de productor que es de escasos recursos, no se realiza un adecuado manejo tanto en el ganado como en la pradera, haciendose una ganadería tradicional y extensiva; en el caso de los animales de traspatio, unicamente se les ofrece desperdicios de comida y poco grano.

4.8.5 Capacidad de carga.- La capacidad de carga de la superficie ganadera, es de 65 U.A.

4.8.6 Producción actual de la explotación.- La ganadería es de tipo familiar y referente a la leche, es de autoconsumo; la producción de leche en promedio por vaca es de 2 lts por día.

4.8.7 Costos de producción.- no se tienen estimados los costos reales derivado que trabajan los productores y sus familias en las labores pecuarias; sin embargo los gastos por concepto de medicinas es de $ 6,500.00.

4.8.8 Valor de la producción. El costo de venta de leche que fluctúa en la zona a $ 2.00; el precio del becerro oscila entre $ 2,400.00 y 2,800.00 dependiendo de las condiciones de hato.

4.8.9 Utilidad.- El producción de leche es de autoconsumo y el ingreso que obtienen en la venta anuales de los becerros es de $ 45,000.00

4.9 Agricultura

4.9.1 Inventario agrícola: 6 ha se utilizan para siembra de maíz criollo, intercalado con frijol y chile para autoconsumo.

4.9.2 Tipo de agricultura: Temporal

4.9.3 Producción actual de la explotación: se tiene una producción de 1.5 toneladas de maíz por hectárea, esta producción es para autoconsumo.

4.9.4 Costos de producción.- La mano de obra es familiar.

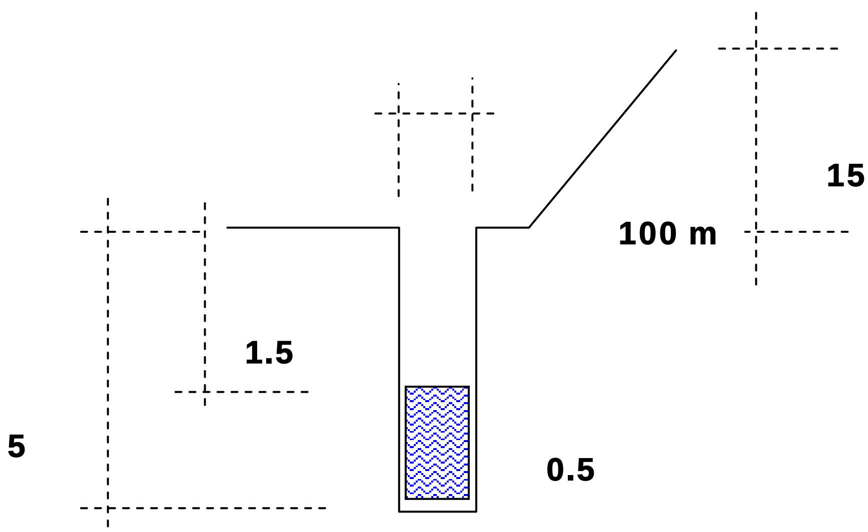
4.9.5 Valor de la producción.- El precio de la tonelada de maíz oscila entre 1,400 y 1,700 pesos.

4.10 Situación económica, créditos vigentes y adeudos: De acuerdo con datos de CONAPO, la localidad está considerada como de alta marginalidad. Los ingresos económicos principales es de los jefes de familia por el jornaleo.

4.11 Problemática: La marginalidad y la escasez de servicios públicos, son los factores principales que dificultan el desarrollo socio-económico de la comunidad.
Por otro lado la extracción de agua se hace en forma manual, lo que dificulta que los productores realicen otras actividades, debido a que pasan la mayor parte del día en esta labor.

5. Estudios Técnicos

5.1 Estudio Topográfico (desnivel entre la fuente de agua y el tanque de almacenamiento): El desnivel topográfico entre la fuente y el tanque de almacenamiento es de 15.0 metros. La fuente se encuentra a una distancia de 100 metros.



5.2 Evaluación de la fuente de agua (producción diaria de agua en litros/minuto): La producción de agua de la fuente en estiaje es 2.6 m3/hr (43.3 litros por minuto).

6. Proyecto

6.1 Justificación: Se plantea el desarrollo de un sistema productivo para el desarrollo del centro comunitario, de la ganadería de traspatio y hortalizas familiares que generen la fuente de ingresos como apoyo para la economía familiar; y además que aporten parte de la alimentación familiar.

Además, como premisa no menos importante, se plantea por parte de los productores, la electrificación de las viviendas, que les permitan mejorar sus condiciones de vida; y del aula escolar, con el objetivo de que los niños de la comunidad tengan mejores oportunidades para su desarrollo educativo.

6.2 Acciones a desarrollar:

Acciones a desarrollar
Iluminación
11 viviendas
Aula escolar
Galera para aves
Subtotal
Bombeo de agua
Abrevadero
Riego de hortaliza familiar
Uso doméstico
Subtotal

6.3 Iluminación en viviendas, aula escolar y galera de aves

6.3.1 Cálculo las demandas energéticas

Electrificación	Concepto	Número	Potencia Watts	Total Potencia	Uso (horas)	Total Energía (watt-hr)
11 viviendas	4 Lamparas x vivienda c.c.	44	13	572	4	2288
	Radio/tocacintas c.c.	11	24	264	4	1056
	T.V. c.c.	11	48	528	4	2112
	Licuadora c.a.	11	300	3,300	0.1	330
Aula escolar	6 Lamparas x aula c.c.	6	20	120	3.5	420
	Radio/tocacintas c.c.	1	24	24	4	96
	T.V. c.c.	1	48	48	4	192
Galera para aves	6 Lamparas x galera c.c.	6	7	42	6	252
TOTAL			**484**	**4,898**		**6,746**

6.4 Bombeo de agua

6.4.1 Cálculo de la demanda de agua

Requerimiento de agua diario		
Abrevadero	M3/día	3.00
Riego de hortaliza familiar	M3/día	1.00
Uso domestico	M3/día	1.00
Subtotal	**M3/día**	**5.00**

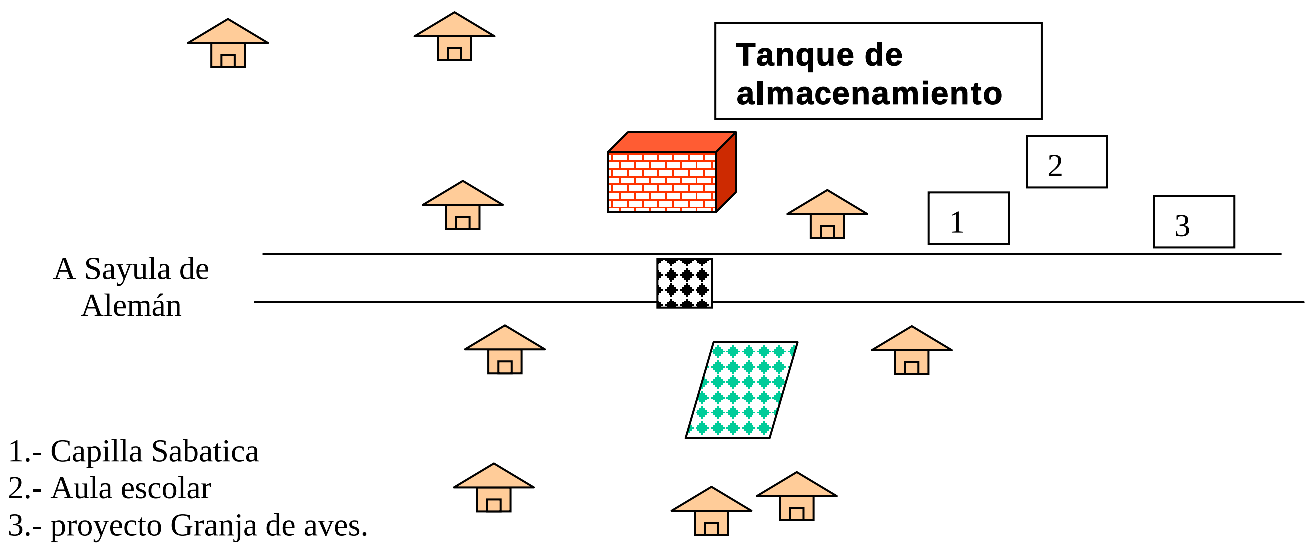
6.4.2 Cargas hidráulicas: La altura total a la que se debe elevar el agua es la carga hidráulica, también denominada Carga Dinámica Total (CDT):

CDT=Desnivel topográfico(15)+nivel estático(1.5)+nivel dinámico(0.50)+ fricción ($hf=klQ^2$)

CDT = 15+1.5+0.50+ 0.70 = 17.07 m

6.4.3 Ubicación de la descarga: La descarga es un tanque de almacenamiento de 10 m3 de capacidad, ubicado a 100 m de la fuente de agua.

6.4.4 Planeación de las líneas de conducción y distribución, tanque de almacenamiento: La línea de conducción, es a base de tubería hidráulica de PVC de 2 pulgadas de diámetro, con 100 metros de longitud hasta el tanque de almacenamiento.



6.5 Diseño de los sistemas fotovoltáicos.- Lo primero que se considera en la instalación de la estructura que soporta al arreglo fotovoltaico, es su localización distante de las zonas inundable,en el presente proyecto, el modulo solar estará a un costado de la fuente de almacenamiento de agua.

6.5.1 Dimensionamiento de arreglos fotovoltáicos y criterios de selección de equipos.- El arreglo fotovoltáico diseñado para operar la bomba que proporcionará el agua, fue elegido de entre 4 propuestas del mismo número de empresas proveedoras de equipos fotovoltáicos. La propuesta más viable, es la que aporta una potencia de 150 watts. El arreglo fotovoltáico esta compuesto por 3 módulos, de 50 Watts de potencia cada uno marca KYOCERA modelo KC-50; su manufactura es a base de sílice monocristalino. Su distribución eléctrica se conforma por un módulo 1 en paralelo y 3 en serie. Con este arreglo se obtendrá la potencia requerida por la bomba Grundfos 11 SQF-2 (Datos técnicos a detalle, en el anexo)

6.5.2 Esquema del arreglo.- El equipo se calculo para una carga dinamica total de 18.00 m, un recurso de 4.5 horas solares pico y un gasto de 5.0m3/día. La potencia instalada es de 150 watts (3 modulos de 50 watts, 3 en serie y 1 en paralelo).

6.5.3 Catálogo de conceptos, presupuesto y especificaciones técnicas
El presupuesto de todas las acciones es de **$ 66,514.17** que incluye los conceptos principales (ver cuadro).

Concepto	***Unidad***	***Cantidad***
Sistema FV	*Equipo*	*1*
Línea de conducción	*Metro*	*100*
Tanque de almacenamiento	*Pieza*	*1*

6.6 Producción agrícola y ganadera esperada:
Producción ganadera: además de que el productor pueda realizar otras actividades ganaderas, se mantendrá en un inicio la producción de leche, sin se espera el mejor condición corporal del ganado, con esto a mediano plazo lograra incrementar la producción en un 20%.

En lo que respecta a la producción agrícola, el cultivo forrajero será maíz, cuya producción servirá como complemento alimenticio del ganado y además para consumo familiar.

Los excedentes de agua serán utilizados para el riego de auxilio de una pequeña hortaliza familiar, en la que se siembren, entre otros: Rábanos, zanahorias, lechugas, espinacas, acelgas, tomates, jitomates, etc., que permita a los productores contar con alimentos sanos y variados para hacer mas nutritiva la alimentación familiar y sin desembolsos económicos.

6.7 Costos de producción estimados en ganadería y en agricultura:

Concepto	**Costos (miles de $)**				
	Año 1	**Año2**	**Año 3**	**Año 4**	**Año 5**
Establecimiento del sistema de riego $10.0 amortizado en 5 años:	2.0	2.0	2.0	2.0	2.0
Medicamentos:	10.0	10.0	10.0	10.0	10.0
Mano de obra	67.0	67.0	67.0	67.0	67.0
Suministro de agua para todas las actividades (bombeo FV) $100.0 amortizado en 25 años	4.0	4.0	4.0	4.0	4.0
Adquisición de semillas p/hortalizas	0.3	0.3	0.3	0.3	0.3
Suministro de iluminación en galera $15.1 amortizado en 10 años	2.0	2.0	2.0	2.0	2.0
TOTAL:	**85.3**	**85.3**	**85.3**	**85.3**	**85.3**

6.8 Valor de la producción esperada agrícola y ganadera

Concepto	Valor ($)				
	Año 1	Año2	Año 3	Año 4	Año 5
Venta de leche	76,650	76,650	82,015	87,756	93,998
Venta de becerros	58,500	58,500	62,595	66,976	71,665
TOTAL:	**135,151**	**135,150**	**144,613**	**154,736**	**165,668**

6.9 Evaluación económica y financiera del proyecto: El proyecto es económicamente viable.

6.10 Estructura de aportaciones:

CONCEPTO	TOTAL	ALIANZA	GEF	USAID	PRODUCTOR
Sistema FV.	46,514.17	23,257.09	13,954.25	0.00	9,302.83
Iluminación en aula escolar, galera y viviendas	136,367.53	0.00	0.00	136,367.53	0.00
Línea de conducción	2,000.00	1,000.00	0.00	0.00	1,000.00
Tanque de almacenamiento	18,000.00	9,000.00	0.00	0.00	9,000.00
Total	**202,881.7**	**33,257.09**	**13,954.25**	**136,367.53**	**19,302.83**

6.11 Período de ejecución de las acciones

Concepto	***Ejecución 2003-2004***			
	Oct	**Nov**	**Dic**	**Ene**
Bombeo de agua F.V.				
Iluminación				
Tanque almacenamiento				

7. ANEXOS.

7.1 Cuadro de cotizaciones, lista de precios de los materiales, equipos y piezas especiales; garantías y especificaciones del fabricante

7.2 Reporte de clima y recurso solar de la zona

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Appendix F – FIRCO Document Arroyo de Caña

SECRETARIA DE AGRICULTURA, GANADERÍA, DESARROLLO RURAL, PESCA Y ALIMENTACIÓN

DELEGACIÓN ESTATAL VERACRUZ

SECRETARÍA DE DESARROLLO AGROPECUARIO RURAL, FORESTAL, PESCA Y ALIMENTACIÓN
GOBIERNO DEL ESTADO DE VERACRUZ

FIDEICOMISO DE RIESGO COMPARTIDO
GERENCIA ESTATAL VERACRUZ

AGENCIA INTENACIONAL PARA EL DESARROLLO DE LOS ESTADOS UNIDOS (USAID)

LABORATORIOS NACIONALES SANDIA

LIANZA PARA EL CAMPO

PROGRAMA DE FOMENTO GANADERO

PROYECTO DE ENERGIA RENOVABLE

PARA EL DESARROLLO RURAL

PROYECTO PRODUCTIVO EN EL
CENTRO DE DESARROLLO COMUNITARIO

“ARROYO DE CAÑA”

ARROYO DE CAÑA, MPIO. ACAYUCAN, VER.
“MICROCUENCA MICHAPAN”

ELECTRIFICACION EN AULA ESCOLAR, GALERA PARA CERDOS Y VIVIENDAS Y BOMBEO DE AGUA PARA ABREVADERO Y RIEGO DE HORTALIZA FAMILIAR
CON EL USO DE ENERGÍA FOTOVOLTAICA

Xalapa, Ver., Septiembre de 2003.

CENTRO DE DESARROLLO COMUNITARIO, “ARROYO DE CAÑA”

ARROYO DE CAÑA, MPIO. ACAYUCAN, VER.

CONTENIDO

1. **Solicitud**
    - 1.1. Solicitud
    - 1.2. Identificación oficial y CURP de productor y beneficiarios.
    - 1.3. Constancia que acredite actividad pecuaria.
    - 1.4. Certificado parcelario y/o escritura de propiedad
2. **Datos generales del Centro de Desarrollo Comunitario**
    - 2.1. Nombre del Centro de Desarrollo Comunitario
    - 2.2. Representante y relación de beneficiarios
    - 2.3. Localidad
    - 2.4. Municipio
    - 2.5. Croquis de localización y ubicación geográfica
    - 2.6. Distancia a la red eléctrica.
3. **Aspectos sociales**
    - 3.1. Población
    - 3.2. Vivienda
    - 3.3. Alimentación
    - 3.4. Salud
    - 3.5. Servicios públicos
    - 3.6. Educación
    - 3.7. Recreación y Religión
    - 3.8. Organización
4. **Aspectos físicos y económicos del Centro de Desarrollo Comunitario**
    - 4.1. Climatología y recurso solar
    - 4.2. Recursos hidráulicos
    - 4.3. Fuente de abastecimiento
    - 4.4. Infraestructura existente
    - 4.5. Maquinaria y equipo
    - 4.6. Superficie total (agrícola, ganadera, forestal)
    - 4.7. Tipo de tenencia de la tierra
    - 4.8. Uso actual del suelo
    - 4.9. Ganadería
        - 4.9.1. Inventario ganadero
        - 4.9.2. Tipo de ganadería
        - 4.9.3. Composición del hato
        - 4.9.4. Prácticas de manejo del hato y la pradera
    - 4.10. Agricultura
        - 4.10.1. Inventario agrícola
        - 4.10.2. Tipo de agricultura
        - 4.10.3. Producción actual de la explotación
    - 4.11. Situación económica, créditos vigentes y adeudos.
    - 4.12. Problemática

5. **Estudios Técnicos**
    5.1. Estudio Topográfico (desnivel entre la fuente de agua y el tanque de almacenamiento)
    5.2. Evaluación de la fuente de agua (producción diaria de agua en litros/minuto)
6. **Proyecto**
    6.1. Justificación
    6.2. Acciones a desarrollar
    6.3. Iluminación en viviendas, aula escolar y galera de cerdos
        6.3.1. Cálculo de la demanda energética
    6.4. Bombeo de agua
        6.4.1. Cálculo de la demanda de agua
        6.4.2. Cargas hidráulicas
        6.4.3. Ubicación de la descarga
        6.4.4. Planeación de las líneas de conducción y distribución, tanque de almacenamiento
    6.5. Diseño de los sistemas fotovoltáicos
        6.5.1. Dimensionamiento de arreglos fotovoltáicos y criterios de selección de equipos
        6.5.2. Esquema de los arreglos
        6.5.3. Catálogo de conceptos, presupuesto y especificaciones *técnicas*
    6.6. Producción esperada agrícola y ganadera
    6.7. Costos de producción estimados agrícola y ganadera
    6.8. Valor de la producción esperada agrícola y ganadera
    6.9. Utilidad
    6.10. Evaluación económica y financiera del proyecto
    6.11. Evaluación general del proyecto
    6.12. Estructura de aportaciones
    6.13. Período de ejecución de las acciones

7. **ANEXOS**.
    7.1. Cuadro de cotizaciones, lista de precios de los materiales, equipos y piezas especiales; garantías y especificaciones del fabricante
    7.2. Reporte de clima y recurso solar de la zona

CENTRO DE DESARROLLO COMUNITARIO, “ARROYO DE CAÑA”

ARROYO DE CAÑA, MPIO. ACAYUCAN, VER.

CONTENIDO

1. Solicitud

1.1. Solicitud

1.2. Identificación oficial y CURP de productor y beneficiarios.

1.3. Constancia que acredite actividad pecuaria.

1.4. Certificados parcelarios y/o escrituras de propiedad

2. Datos generales del Centro de Desarrollo Comunitario

2.1. Nombre del Centro de Desarrollo Comunitario: Arroyo de Caña

2.2. Representante y relación de beneficiarios: C. Eledi Ledezma Cortés.
Eufrocina Herrera Ruperto
Liliana Aguilera Carmona
Esperanza Aguilera Carmona
Rosa Ruperto

2.3. Localidad: Arroyo de Caña

2.4. Municipio: Acayucan, Ver.

2.5. Croquis de localización y ubicación geográfica:

El Proyecto Productivo esta ubicado dentro del municipio Acayucan, Ver., en la región sur del estado. Fisiográficamente en la Llanura Costera del Golfo Sur, en la sub-provincia Llanura Costera Veracruzana con lomeríos suaves con cañadas. Se ubica a 17º 58’ 47’’ de latitud norte y 94º 57’ 14’’ de longitud oeste, a 70 metros sobre el nivel del mar.

El recorrido para llegar al sitio del proyecto, desde la ciudad de Acayucan, Ver., es 8 km por terracería, accesible todo el año. A 60 km del Aeropuerto Canticas en Minatitlán, Ver.

2.6. Distancia a la red eléctrica: La comunidad de arroyo de caña, no cuenta con el servicio de electricidad, existiendo 3 kilometros de distancia hasta la siguiente comunidad que si cuenta con ese servicio básico, sin posibilidad de extenderse a las inmediaciones del proyecto. Esta situación hace viable la instalación del sistema de bombeo con el uso de paneles solares.

3. Aspectos socials

3.1. Población: 98 habitantes.

3.2. Vivienda: Existen 18 viviendas con paredes de adobe (bambú y arcilla) con techumbre de palma, sin servicios sanitarios.

3.3. Alimentación: Su alimentación es a base de tortillas de maíz, frijoles, huevos y en algunos fines de semana carne de pollo o cerdo.

3.4. Salud: No se cuenta con instalaciones de instituciones de seguridad social, en caso de requerir atención médica los habitantes acuden al municipio de Acayucan, Ver. Las enfermedades más comunes que se presentan en la población son: gripas e infecciones gastrointestinales, se reportan casos de diabetes y presión arterial, pero en general se puede decir que el estado físico de la población es aceptable.

3.5. Servicios públicos: El único servicio público con que cuenta la comunidad es un aula escolar de nivel preescolar y primaria, atendida por 3 maestros CONAFE.

3.6. Educación: Actualmente acuden a la escuela de la comunidad 23 niños, de los cuales 18 cursan la educación primaria en los 3 niveles que maneja CONAFE, y 5 cursan el nivel preescolar. El nivel escolar en la población mayor de 15 años es de tercer grado de primaria.

3.7. Recreación y Religión: Las principales festividades de la comunidad son la Semana Santa, Día de muertos, Navidad y Fiestas patronales de Martín Obispo de Acayucan; además las fiestas patrias.

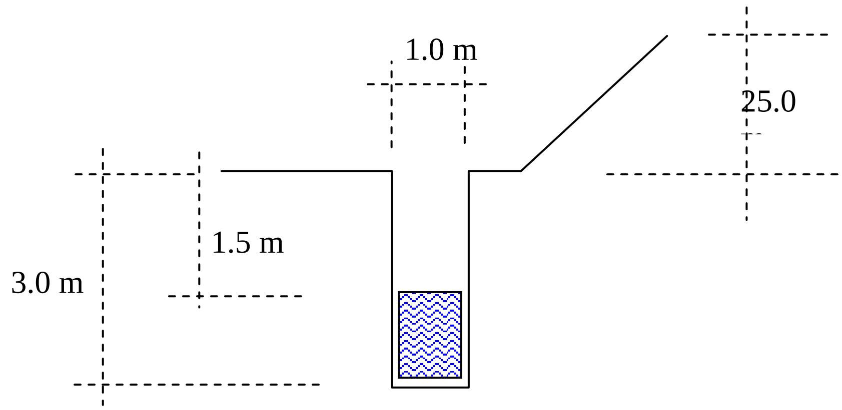
3.8. Organización: La principal organización se basa en las costumbres y tradiciones. Actualmente están organizados en un comité pro-electrificación cuya función principal es solicitar apoyo a las autoridades municipales para la implementación de "plantas solares".

4. Aspectos físicos y económicos del Centro de Desarrollo Comunitario

4.1. Climatología y recurso solar: La temperatura media anual es de 26.1ºC, con máximas de 34.9ºC en el mes de abril; lluvias en verano, con una precipitación de 1,403.1 mm anuales. El número de días nublados cerrados es de 99, sin embargo el recurso solar promedio diario es aceptable con 4.5 horas solares pico. Estos datos climatológicos fueron tomados de estadísticas resultantes de un período de observación de 10 años (1971-1980) de la estación climatológica San Juanillo ubicada en la localidad San Juan del Llano en el municipio de Acayucan, lugar cercano al sitio del proyecto.

4.2. Recursos hidráulicos: La unidad de Producción se ubica en la Región Hidrológica No. 18 cuenca del Papaloapan.

4.3. Fuente de abastecimiento: Las necesidades de agua del centro comunitario, se cubren con una noria ubicada a 250 metros del núcleo poblacional. La noria tiene las siguientes características. Se ubica 25 metros abajo del núcleo poblacional (desnivel topográfico). Tiene 3 metros de profundidad, cuenta con ademe de anillos metálicos. El nivel estático se ubica a 1.5 metros y el nivel dinámico a 2.0 metros. La producción de agua de la fuente en estiaje es 2.5 m3/hr.



4.4. Infraestructura existente: La infraestructura con que cuentan sólo es la fuente de agua y algunos cercos con alambre de púas. Existe un corral rústico donde pernoctan los animales de carga: 5 asnos.

4.5. Maquinaria y equipo: Cuentan con herramienta menor: machetes, limas, azadones y bombas de mochila.

4.6. Superficie total (agrícola, ganadera, forestal): La comunidad se compone de 36 hectáreas, de las cuales 1 hectárea es del fondo legal y el resto dedicadas principalmente a la siembra de maíz para autoconsumo. Pequeñas superficies (5 ha) se utilizan para el pastoreo del ganado de traspatio y de las bestias de carga.

4.7. Tipo de tenencia de la tierra: Se encuentran bajo el régimen jurídico ejidal dentro del ejido "Acayucan".

4.8. Uso actual del suelo: Agricultura de básicos para autoconsumo y pastoreo de ganado de traspatio.

4.9 Ganadería

4.9.1 Inventario ganadero: 15 cerdos de raza criolla, gallinas, guajolotes y 5 asnos.

4.9.2 Tipo de ganadería: Traspatio.

4.9.3 Composición del hato: 15 cerdos en etapa de engorda, gallinas, guajolotes y 5 asnos.

4.9.4 Prácticas desarrolladas en el manejo del hato y la pradera: No se lleva control sanitario o productivo de algún tipo, la alimentación es a base de los desperdicios de la alimentación familiar y del pastoreo extensivo.

4.10 Agricultura

4.10.1 Inventario agrícola: 20 ha se utilizan para siembra de maíz criollo, intercalado con frijol, calabaza, chile. Las 15 ha restantes cuentan con gramas nativas.

4.10.2 Tipo de agricultura: Temporal

4.10.3 Producción actual de la explotación: Autoconsumo.

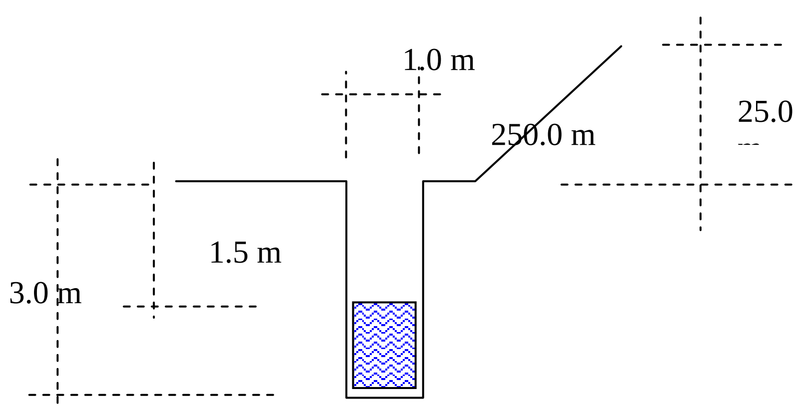
4.11 Situación económica, créditos vigentes y adeudos: De acuerdo con datos de CONAPO, la localidad está considerada como de extrema pobreza. Los ingresos económicos principales es de los jefes de familia por el jornaleo.

4.12 Problemática: La marginalidad, la escasez de servicios públicos y la pobreza extrema son los factores principales que dificultan el desarrollo socio-económico de la comunidad.

Respecto a la cría de cerdos, se desarrolla bajo condiciones de libre pastoreo y al atardecer se acercan al núcleo poblacional para pernoctar. Esta costumbre de crianza de los cerdos, sumado a que los habitantes realizan sus necesidades fisiológicas al aire libre, genera un problema de salud.

5. Estudios Técnicos

5.1 Estudio Topográfico (desnivel entre la fuente de agua y el tanque de almacenamiento): El desnivel topográfico entre la fuente y el tanque de almacenamiento es de 25.0 metros. La fuente se encuentra a una distancia de 250 metros.



5.2 Evaluación de la fuente de agua (producción diaria de agua en litros/minuto): La producción de agua de la fuente en estiaje es 2.5 m3/hr (42 litros por minuto).

6. Proyecto

6.1 Justificación: Se plantea el desarrollo de un sistema productivo eficiente de ganadería de traspatio y hortalizas familiares que generen la fuente de ingresos como apoyo para la economía familiar; y además que aporten parte de la alimentación familiar.

Además, como premisa no menos importante, se plantea por parte de los productores, la electrificación de las viviendas, que les permitan mejorar sus condiciones de vida; y del aula escolar, con el objetivo de que los niños de la comunidad tengan mejores oportunidades para su desarrollo educativo.

6.2 Acciones a desarrollar:

Acciones a desarrollar
Iluminación
18 viviendas
Aula escolar
Galera para cerdos
Subtotal
Bombeo de agua
Abrevadero y limpieza para 30 cerdos
Riego de hortaliza familiar ¼
Consumo humano
Subtotal

6.3 Iluminación en viviendas, aula escolar y galera de cerdos

6.3.1 Cálculo de la demanda energética.-

Electrificación	Concepto	Número	Potencia Watts	Total Potencia (watts)	Uso (horas)	Total Energía (watt-hr)
Viviendas (18)	Lamparas fluorescentes	72	13	936	4	3744
	Radio/tocacintas c.c.	18	35	630	4	2520
	T.V. 14"	18	48	864	4	3456
	Licuadora c.a.	18	300	5,400	0.1	540
TOTAL				**7,830**		**10,260**

Electrificación	Concepto	Número	Potencia Watts	Total Potencia (watts)	Uso (horas)	Total Energía (watt-hr)
Aula escolar	6 Lamparas x aula c.c.	6	13	78	3.5	273
	Radio/tocacintas c.c.	1	35	35	4	140
	T.V. c.c.	1	48	48	4	192
TOTAL				**161**		**605**

Electrificación	Concepto	Número	Potencia Watts	Total Potencia (watts)	Uso (horas)	Total Energía (watt-hr)
Galera para cerdos	Lamparas x galera c.c.	6	13	78	6	468
TOTAL				**78**		**468**

6.4 Bombeo de agua

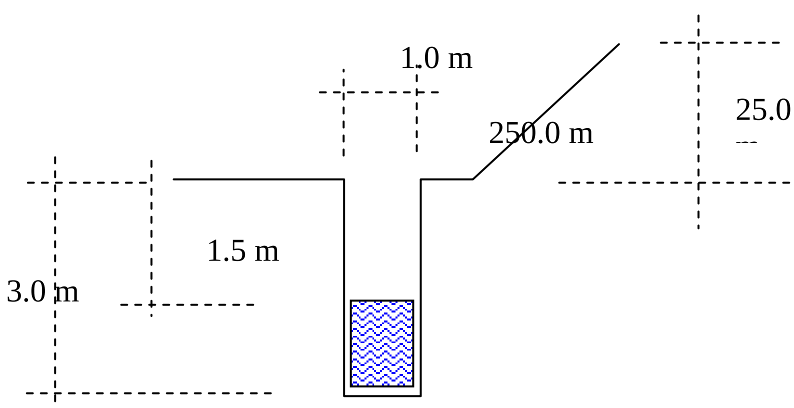
6.4.1 Cálculo de la demanda de agua

Requerimiento de agua diario		
Abrevadero y limpieza para 30 cerdos	M3/día	0.80
Riego de hortaliza familiar	M3/día	1.00
Uso doméstico	M3/día	3.00
Subtotal	**M3/día**	**4.80**

6.4.2 Cargas hidráulicas: La altura total a la que se debe elevar el agua es la carga hidráulica, también denominada Carga Dinámica Total (CDT):

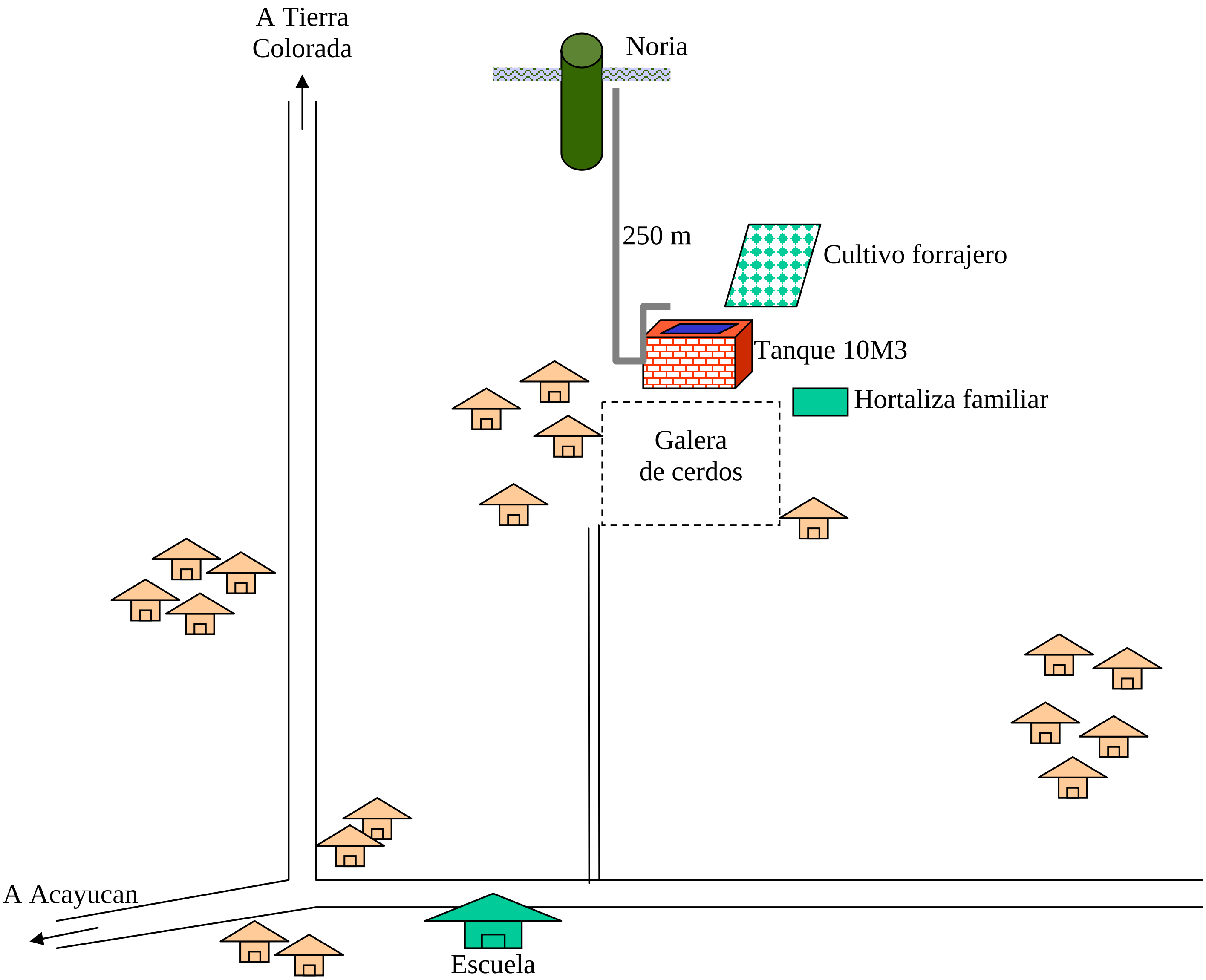
CDT=Desnivel topográfico(25)+nivel estático(1.5)+nivel dinámico(0.50)+ fricción ($hf=klQ^2$)

CDT = 25+1.5+0.50+ 0.16 = 27.16 m



6.4.3 Ubicación de la descarga: La descarga es un tanque de almacenamiento de 10 m3 de capacidad, ubicado a 250 m de la fuente de agua.

6.4.4 Planeación de las líneas de conducción y distribución, tanque de almacenamiento: La línea de conducción, es a base de tubería hidráulica de PVC de 2 pulgadas de diámetro, con 250 metros de longitud hasta el tanque de almacenamiento.



6.5 Diseño de los sistemas fotovoltáicos.- Lo primero que se considera en la instalación de la estructura que soporta al arreglo fotovoltaico, es su localización distante de las zonas inundable,en el presente proyecto, el modulo solar estará a un costado de la fuente de almacenamiento de agua.

6.5.1 Dimensionamiento de arreglos fotovoltáicos y criterios de selección de equipos.- El arreglo fotovoltáico diseñado para operar la bomba que proporcionará el agua, fue elegido de entre 3 propuestas del mismo número de empresas proveedoras de equipos fotovoltáicos. La propuesta más viable, es la que aporta una potencia de 240 watts. El arreglo fotovoltáico esta compuesto por 3 módulos, de 80 Watts de potencia cada uno marca KYOCERA modelo KC-80; su manufactura es a base de sílice monocristalino. Su distribución eléctrica se conforma por un módulo 1 en paralelo y 3 en serie. Con este arreglo se obtendrá la potencia requerida por la bomba Grundfos 11 SQF-2 (Datos técnicos a detalle, en el anexo)

6.5.2 Esquema del arreglo.- El equipo se calculo para una carga dinamica total de 28.20 m, un recurso de 4.5 horas solares pico y un gasto de 4.8m3/día. La potencia instalada es de 240 watts (3 modulos de 80 watts, 3 en serie y 1 en paralelo).

6.5.3 Catálogo de conceptos, presupuesto y especificaciones técnicas
El presupuesto de todas las acciones es de **$ 78,228.06** que incluye los conceptos principales (ver cuadro).

Concepto	***Unidad***	***Cantidad***
Sistema FV	*Equipo*	*1*
Línea de conducción	*Metro*	*250*
Tanque de almacenamiento	*Pieza*	*1*

6.6 Producción agrícola y ganadera esperada:
Producción ganadera: La implementación de la galera permitirá confinar a los cerdos y con ello tener un adecuado control sanitario. Con esta medida se podrá comercializar la carne con las comunidades vecinas, sin el temor de contagios del parásito que causa la "cisticercosis". Adicionalmente, la comunidad está considerada en un programa social que les apoyará para la construcción de letrinas. La capacidad de confinamiento de la galera es de 30 cerdos, con dimensión de 10.0 m x 3.0 m., con divisiones que permitan separar los machos, las hembras y los lechones.

Inicialmente se engordará un número pequeño de cerdos, que paulatinamente se incrementará hasta alcanzar los niveles máximos de producción (se logrará engordar hasta 30 cerdos), cuya alimentación inicialmente será a base de el maíz producido en la comunidad, y conforme se alcancen los niveles máximos esperados, se adquirirá alimento balanceado.

En promedio cada cerdo para venta alcanza un peso de 100 kg y el precio en el mercado por mayoreo es de $14.00/kg., anualmente tendrán la capacidad de sacar al mercado 20 cabezas (2.0 toneladas/año)

En lo que respecta a la producción agrícola, el cultivo forrajero será maíz, cuya producción servirá como complemento alimenticio del ganado y además para consumo familiar.

Los excedentes de agua serán utilizados para el riego de auxilio de una pequeña hortaliza familiar, en la que se siembren, entre otros: Rábanos, zanahorias, lechugas, espinacas, acelgas, tomates, jitomates, etc., que permita a los productores contar con alimentos sanos y variados para hacer mas nutritiva la alimentación familiar y sin desembolsos económicos.

6.7 Costos de producción estimados en ganadería y en agricultura:

Concepto	**Costos (miles de $)**				
	Año 1	**Año2**	**Año 3**	**Año 4**	**Año 5**
Rehabilitación de galera $10.0 amortizada en 10 años:	1.0	1.0	1.0	1.0	1.0
Establecimiento del sistema de riego $10.0 amortizado en 5 años:	2.0	2.0	2.0	2.0	2.0
Adquisición de alimento:	0.0	0.0	5.3	10.5	10.5
Medicamentos:	2.0	2.0	2.0	2.0	2.0
Mano de obra (mano de obra de los productores:	0.0	0.0	0.0	0.0	0.0
Suministro de agua para todas las actividades (bombeo FV) $100.0 amortizado en 25 años	4.0	4.0	4.0	4.0	4.0
Adquisición de semillas p/hortalizas	0.3	0.3	0.3	0.3	0.3
Suministro de iluminación en galera $15.1 amortizado en 10 años	2.0	2.0	2.0	2.0	2.0
Fletes:	0.5	0.5	1.0	1.0	1.0
TOTAL:	**11.8**	**11.8**	**17.6**	**22.8**	**22.8**

6.8 Valor de la producción esperada agrícola y ganadera

Concepto	**Valor (miles de $)**				
	Año 1	Año2	Año 3	Año 4	Año 5
Venta de ganado llegado:	10 cerdos $14.0	15 cerdos $21.0	25 cerdos $35.0	30 cerdos $42.0	30 cerdos $42.0
Hortalizas	$1.0	$1.0	$1.0	$1.0	$1.0
TOTAL:	**$15.00**	**$22.00**	**$36.00**	**$43.00**	**$43.00**

6.9 Utilidad

Concepto	Utilidad (miles de $)				
	Año 1	Año2	Año 3	Año 4	Año 5
Costos:	11.80	11.80	17.6	22.8	22.8
Valor:	15.00	22.00	36.00	43.00	43.00
UTILIDAD:	**3.20**	**10.20**	**18.40**	**20.20**	**20.20**

6.10 Evaluación económica y financiera del proyecto: El proyecto es económicamente viable.

6.11 Evaluación general del proyecto: Tomando en cuenta que actualmente la localidad realiza las actividades de una manera precaria y sin percepción de recursos económicos, y que con la implementación del proyecto, atraerá los recursos complementarios para las necesidades de la localidad y de manera individual para cada familia. Con lo anterior, técnica y económicamente el proyecto se considera viable al otorgar elementos a los miembros de la localidad para satisfacer sus necesidades mas elementales de una manera sustentable y con las medidas sanitarias que otorgarán una mejor forma de vida de todos ellos.

6.12 Estructura de aportaciones*:*

CONCEPTO	TOTAL	ALIANZA	GEF	USAID	PRODUCTOR
Sistema FV. Bombeo	55,228.08	27,614.03	16,568.42	0.00	11,045.61
Iluminación en aula escolar, galera y viviendas	203,639.44	0.00	0.00	239,639.44	0.00
Línea de conducción	5,000.00	2,500.00	0.00	0.00	2,500.00
Tanque de almacenamiento	18,000.00	9,000.00	0.00	0.00	9,000.00
Sistema de riego	10,000.00	0.00	0.00	0.00	10,000.00
Rehab. de galera para cerdos	10,000.00	0.00	0.00	0.00	10,000.00
Total	**301,867.52**	**39,114.03**	**16,568.42**	**239,639.44**	**42,545.61**

Período de ejecución de las acciones

Concepto	***Ejecución 2003-2004***			
	Oct	**Nov**	**Dic**	**Ene**
Bombeo de agua F.V.		X		
Iluminación		X		
Sistema de riego			X	
Tanque almacenamiento		X		
Rehab. de galera para cerdos				X

7. ANEXOS.

7.2 Cuadro de cotizaciones, lista de precios de los materiales, equipos y piezas especiales; garantías y especificaciones del fabricante

7.3 Reporte de clima y recurso solar de la zona